A practical course in wooden boat and ship building

Richard Montgomery Van Gaasbeek

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A PRACTICAL COURSE

in WOODEN BOAT *and*

SHIP BUILDING

The Fundamental Principles and Practical Methods Described in Detail

Especially Written for Carpenters and Other Woodworkers Who Desire to Engage in Boat or Ship Building, and as a Text-book for Schools

By

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FULLY ILLUSTRATED

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PREFACE

To meet a popular demand for a text-book to assist the great army of house carpenters and other woodworkers in transferring from their usual occupations to the wooden boat and ship building industries, now rapidly developing in this country, and especially for those men who wish to qualify for advanced positions, and for boat and ship builders who wish to broaden their experience in order that they may prepare for greater responsibilities, this work is offered.

The text is the outgrowth and development of a pioneer course organized early in the war by Pratt Institute, Brooklyn, N. Y., in response to the demand caused by shortage of skilled labor in these industries.

It was a study to know how to organize the work effectively, to select only those problems that otherwise might take years of labor in the industry for these men to solve, and to present the problems progressively and in such a way that the men would grasp the basic principles in the shortest possible time.

It has been the aim of the author to establish a fundamental course,—one that would help the ship builder as well as the boat builder; for whatever the size or type of the vessel, the general principles

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of construction remain very much the same in all cases.

Those who master this course can direct the labor of others, because they themselves will have learned by doing, and it is only by manipulative skill that a practical understanding of the subject can be acquired.

It was out of the question to build a full-size ship. The space and equipment necessary to handle heavy timbers, the cost of the lumber itself, and the extra labor that would be required of the men after a hard day's work, were all factors to be considered in determining the kind of instruction that would best meet the emergency situation.

We have built a full-size boat, using full-size timbers, and under exact factory conditions, and with the scarfing and adzing of heavy yellow-pine timbers and practice calking, both light and heavy, a course has developed, which, judging from the reports from the men as to their advancement and success in the industry after completing the course, has been most gratifying.

The author has not attempted to give a complete treatise on the subject and therefore offers no apology for any omissions that may be found. The first part of the work (Chapters I to IV) is strictly technical in character, giving the operations in sequence as they were performed on the job and explaining them in such a way that the average mechanic can understand. In the second part (Chapters V to VIII) an effort is made to show

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typical ship construction views, giving the reader an idea of some of the labor-saving devices and methods of handling and fastening heavy timbers.

Chapter IX gives the latest recommendations of The American Bureau of Shipping for the shifting of scarphs and fastenings of wooden vessels, so vital to the safety of an ocean-going ship.

The author wishes to express his appreciation of the generous assistance given by Messrs. Chas. Rassiga, Jr., Edward J. Weber and Harvey R. Saylor, his co-workers, and to leading wooden ship builders and manufacturers, without whose aid this work would have been impossible.

Particularly the author wishes to acknowledge his indebtedness to Mr. W. G. Hudson, District Supervisor, Wood Hull Construction, Second District, Emergency Fleet Corporation; Mr. Theodore E. Ferris, Naval Architect, The American Bureau of Shipping; The Foundation Company, agents of the United States Shipping Board, Emergency Fleet Corporation; Messrs. Tams, Lemoine and Crane; Stetson Machine Works; Messrs. J. A. Fay & Egan Company and Messrs. C. R. Durkee & Co.; Shipbuilders' Pneumatic Tool Co., Inc.; for permission to use the drawings and photographs used in illustrating the second part of the work.

THE AUTHOR.

Pratt Institute,
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A PRACTICAL COURSE IN WOODEN BOAT AND SHIP BUILDING

CHAPTER I

THE MOULD LOFT

The principal drawing of a vessel is the sheer drawing. It is composed of three parts, mutually dependent upon each other, as follows:

Sheer Plan.—Figure 1.—A side view showing length of vessel and heights of sheer or gunwale.

Half-breadth Plan.—Figure 2.—A top view, showing a horizontal or floor plan on any water lines.

Body Plan.—Figure 3.—An end view, showing curves of the frame lines outside the timber at any point in the vessel. Frame lines forward of the midship section are on the right of the center line; aft of the midship section on the left of the center line.

TABLE OF OFFSETS

The table of offsets exhibits the distances from a center or base line. These offsets are compiled by the naval architect and are used by the mould loftsman in laying down the lines on the floor. Just how these offsets are compiled is only of pass-

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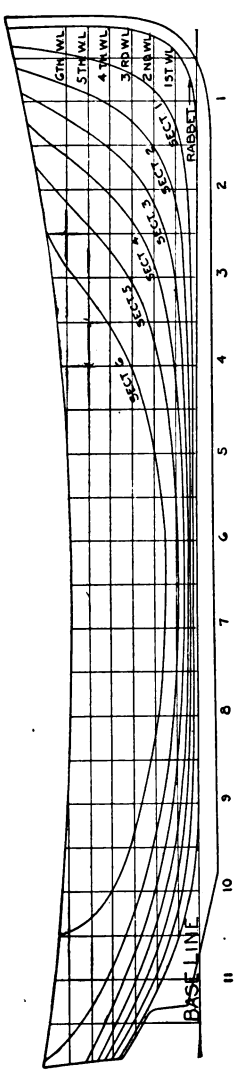

Figure 1.—Sheer Plan—Moulded Lines.

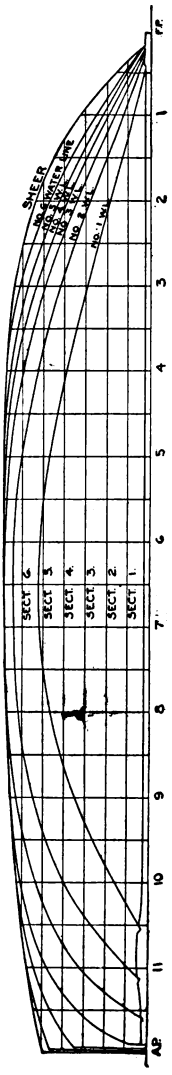

Figure 2.—Half-breadth Plan—Moulded Lines.

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ing interest to the reader, as it is the purpose of this work to help the mechanic to apply them.

Model for Taking Off Offsets.—The most practical way of taking off the offsets is to make a model of wood, an invention of an American mechanic. The model must be made to an exact

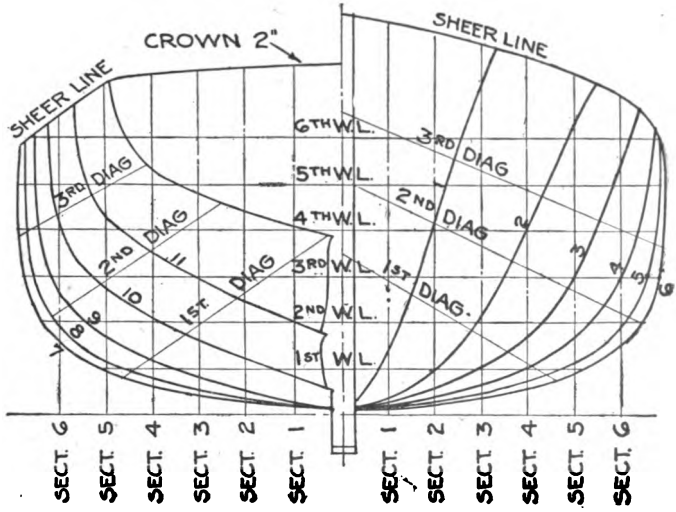

Figure 3.—Body Plan—Moulded Lines.

scale, usually ¼″ to 1′, and it is generally composed of two kinds of soft wood of different colors, such as pine and cedar, in alternate layers screwed or pinned together. The seams between the layers represent the water lines.

The model usually represents the starboard half of the vessel and has a plane side, represent-

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ing the longitudinal midship plane, on which the sheer plan is drawn. Its curved side is then gradually carved, shaved, and filed to such a form as to satisfy the eye and the judgment of the designer.

It is very important, in making the model, to fair up perfectly every portion, so that one portion of it assimilates with the other. If the model is made to a small scale, the discrepancies can be more readily detected, because the whole of the model can be seen at a glance and the inequalities of one end as compared with the other will be discovered. The model must be perfectly fair, not only on all lines, but in every direction.

Station lines, rabbet line and bearding line, and all water lines are laid off to the same scale on the model. The layers can then be separated and from these the table of offsets is scaled. The accuracy with which the model is scaled will save the time of the mould loftsman in laying down his lines.

MOULD LOFT WORK

Laying Off of the Lines.—The laying off of the lines on the mould loft floor can be compared with the foreman's layout in carpenter work. (See Figure 4.) It is the name given to the process of drawing the lines of a vessel to full size in plan and elevation, in order to determine the exact dimensions of the most important and fundamental parts of the structure. The necessity for drawing to full size arises from the extreme accuracy with which the dimensions of the various parts must

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correspond with one another in order that when assembled there may be no irregularity or unfairness in the surface of the vessel.

If the mould loft is not long enough for laying down the vessel full length, it can be laid down in

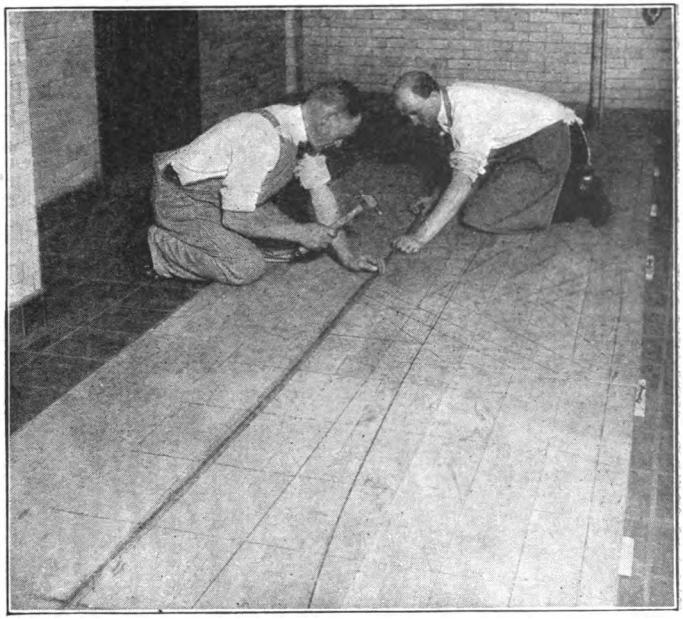

Figure 4.—Fairing-in a Line on Mould Loft Floor.

sections, one overlapping the other, providing the sections are long enough to properly fair up the lines. If the vessel is very large, this is an important operation, for while looking at one part of the line, it may be impossible to see the other side of the same line. Figure 4 shows a section of the

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TABLE OF OFFSETS

Water Lines Spaced 3 Inches	Stations Spaced 12" Center Line to Center Line.				
Section Lines Spaced 3 Inches	Stem	1	2	3	4
Height of Gunwale Above Base..	2-2-0	1-11-6+	1-9-5	1-7-7+	1-6-5
Height of Rabbet Above Base...	.....	0- 0-3	.....	.....	.....
Half-Breadth of Gunwale.....	.....	0-10-0	1-4-2	1-7-2	1-8-2
Half-Breadth of Water Line No. 1	.....	0-2-1+	0- 5-4+	0-8-7	0-11-6+
Half-Breadth of Water Line No. 2	.....	0-3-5+	0- 8-4	1-0-6	1- 4-0
Half-Breadth of Water Line No. 3	.....	0-4-7	0-10-3	1-2-7	1- 5-7+
Half-Breadth of Water Line No. 4	.....	0-5-7	0-11-6	1-4-2+	1- 7-1
Half-Breadth of Water Line No. 5	.....	0-6-5	1- 1-1	1-5-4	1- 7-6
Half-Breadth of Water Line No. 6	.....	0-7-5	1- 2-3	1-6-4+	1- 8-1+
Height of Sec. No. 1 Above Base	.....	0-4-4	0-1-3+	0-0-7+	0-0-6
Height of Sec. No. 2 Above Base	.....	0-1-3	0-3-3	0-1-6	0-1-2+
Height of Sec. No. 3 Above Base	.....	1-9-4	0-6-5	0-3-1	0-2-0
Height of Sec. No. 4 Above Base	.....	.....	0-1-3	0-5-1	0-3-0+
Height of Sec. No. 5 Above Base	.....	.....	1-7-0+	0-9-1	0-5-0
Height of Sec. No. 6 Above Base	.....	.....	.....	1-4-2	0-9-1
	Base Line	W. L. 1	W. L. 2	W. L. 3	W. L. 4
Rabbet from F. P.....	1- 5-6	0-5-5	0-3-0	0-2-2	0-1-7
Rabbet from A. P.....	2-10-4	1-5-0+	0-9-7+	0-4-4	.....
Fore Edge of Stem From F. P...	0- 5-7+	0-2-3	0-1-0+	0-0-4	0-0-1+

mould loft floor at Pratt Institute, Brooklyn, N. Y. The men are fairing-in a line, as can be seen; that is, making its curve true and regular. A mechanical eye will save a great deal of labor, for much depends upon the fairing-in of the lines, as considerable injury may be done to a good design by deviating from the drawings.

THE SHEER PLAN

To lay off the sheer plan, Figure 1, first produce the base line and run the water lines in parallel

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TABLE OF OFFSETS

Stations Spaced 12″ Center Line to Center Line.

5	6	7	8	9	10	11	Transom
1-5-7	1-5-4+	1-5-4	1-5-6	1-6-1+	1-7-0+	1-8-1+	1- 9-6
.....	.....	.....	.....	.....	0-1-1+	0-5-0	0-11-5
1-8-4+	1-8-5	1-8-4+	1-8-1+	1-7-4+	1-6-5	1-5-0+	1- 2-6
1-2-1+	1-3-4	1-3-4	1-1-7	0-10-2+	0- 4-5	.....	.....
1-6-1+	1-7-2	1-7-2+	1-6-3+	1- 4-3	0-11-6+	0-2-5	.....
1-7-5+	1-8-3	1-8-2+	1-7-7	1- 6-5+	1- 3-6	0-9-3	.....
1-8-2	1-8-4	1-8-4	1-8-1	1- 7-3+	1- 6-0+	1-2-1	0- 1-7+
1-8-4	1-8-5	1-8-4	1-8-1+	1- 7-4+	1- 6-4+	1-4-2	0-10-1+
.....	.....	.....	.....	1- 7-4+	1- 6-5	1-4-7+	1- 1-6+
0-0-5+	0-0-5	0-0-5+	0-0-6	0-0-7+	0-2-3	0- 6-1	1-0-2+
0-1-1	0-1-0	0-1-0+	0-1-1	0-1-6	0-3-4	0- 7-3	1-1-2+
0-1-5	0-1-3	0-1-3+	0-1-6	0-2-4+	0-4-5	0- 8-6	1-2-3
0-2-2	0-1-7	0-1-7+	0-2-3	0-3-5	0-6-1	1-10-4	1-4-0+
0-3-2+	0-2-6	0-2-6+	0-3-4	0-5-0	0-8-0	1- 0-7	.....
0-5-6	0-4-3	0-4-4	0-5-4	0-7-7+	1-0-0	.....	.....
W. L. 5	W. L. 6	Sheer					
0-1-6	0-1-6	0-1-6					
.....	.....	.....					
0-0-1	0-0-1	0-0-1					

to the base line. Then strike in the station lines at right angles to the base line and equidistant apart.

The method of laying down one or two lines will suffice to give the reader enough information to enable him to complete the layout. We will assume that the vessel has been outlined and will therefore lay off the sheer line and section 5.

To lay off the sheer line refer to top line of the table of offsets. This gives the heights of gunwale or sheer above the base line. Point off these dis-

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tances on the various stations from the base line. The first figure represents feet, the second inches, and the third eighths, as follows:

At the stem, 2′ 2″; on station 1, 1′ 11 6/8″; station 2, 1′ 9⅝″; station 3, 1′ 7⅞″; station 4, 1′ 6⅝″; station 5, 1′ 5⅞″; station 6, 1′ 5 4/8″; station 7, 1′ 5 4/8″; station 8, 1′ 5 6/8″; station 9, 1′ 6⅛″; station 10, 1′ 7″; station 11, 1′ 8⅛″, and at the transom, 1′ 9 6/8″.

Drive a small nail in at these points and bend a thin batten so as to approximate as closely to these points as is consistent with absolute fairness and continuity. If the batten does not spring well to these points, it is best to pass the batten inside some and outside others in order to prevent great deviation from the design in either direction.

Likewise refer to section 5 on the sheer plan and height of section 5 above base in the table of offsets. Point off on each station line as shown, namely, station 2, 1′ 7″; station 3, 0′ 9⅛″; station 4, 0′ 5″; station 5, 0′ 3 2/8″; station 6, 0′ 2 6/8″; station 7, 0′ 2 6/8″; station 8, 0′ 3 4/8″; station 9, 0′ 5″; station 10, 0′ 8″, and station 11, 1′ 0⅞″. Drive a small nail in at these points and bend a thin batten through them as described in the preceding paragraph.

HALF-BREADTH PLAN

To lay off the half-breadth plan, Figure 2, strike a line representing the center line and mark in the stations of the frames as shown. Set up from the

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center line on the various stations the half-breadths of the water lines and sheer lines, taking the distance from the table of offsets.

The method of laying down the half-breadths of water line No. 2 will show the reader enough to enable him to complete the layout. Refer to the table of offsets, half-breadth of water line No. 2.

Point off these distances on the various stations from the center line, namely, on frame 1, 3⅝″; frame 2, 8 4/8″; frame 3, 1′ 0 6/8″; frame 4, 1′ 4″; frame 5, 1′ 6⅛″; frame 6, 1′ 7 2/8″; frame 7, 1′ 7 2/8″; frame 8, 1′ 6⅜″; frame 9, 1′ 4⅜″; frame 10, 0′ 11 6/8″; frame 11, 0′ 2⅝″. Drive small nails at these points, and bend a thin batten through them, passing it inside some and outside others as need be in order to properly fair up the lines, as explained in a previous paragraph.

BODY PLAN

To lay off the body plan, Figure 3, first produce the base line and then the center line. Lay off the water lines parallel to the base line and the station lines parallel to the center line. Scale off from these lines on the drawing the various frame lines and transfer these locations to the mould loft floor, taking all measurements from the corresponding line. Drive in small nails at these points and bend a thin batten, fairing up the line as may be required before striking in the line.

NOTE.—See page 94 for full description of method of laying off body plan.

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CHAPTER II

STEM AND STERN CONSTRUCTION

The stem is made up of four members, namely, Stem, Lower Stem, Apron, and Deadwood. The stern is made up of six members, Stern Post, Stern Post Knee, Shaft Log, Deadwood, Horn Timber and Transom.

Stem.—The stem (Figure 5) is the foremost boundary of the boat, being a continuation of the keel to the height of the vessel, at the fore extremity.

Lower Stem.—The lower stem is a curved piece placed in the angle formed by the apron and the upper end of the deadwood.

Apron.—The apron is the upper member of the stem on the inboard side of the boat. It is intended to strengthen the stem and afford wood for the reception of the outside planking and the heels of the foremost timber.

Deadwood.—The deadwood is the lower member of the stem on the inboard side of the boat. The deadwood becomes the foundation against which the heels of the forward frames are abutted.

Stern Post.—The stern post (Figure 6) forms the after boundary of the frame of the boat, being the after continuation of the keel to the height of

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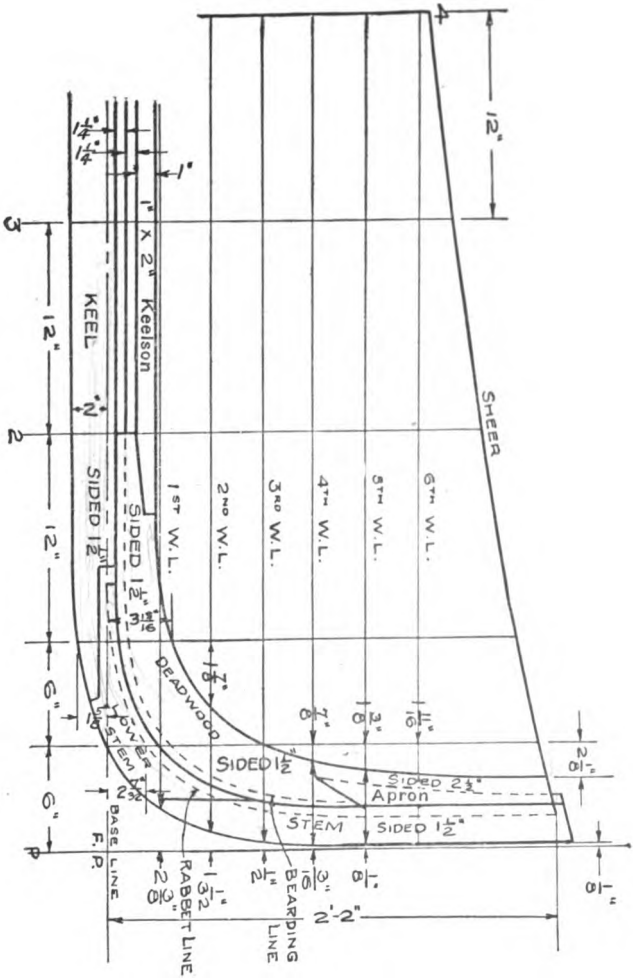

Figure 5.—Detail of Stem

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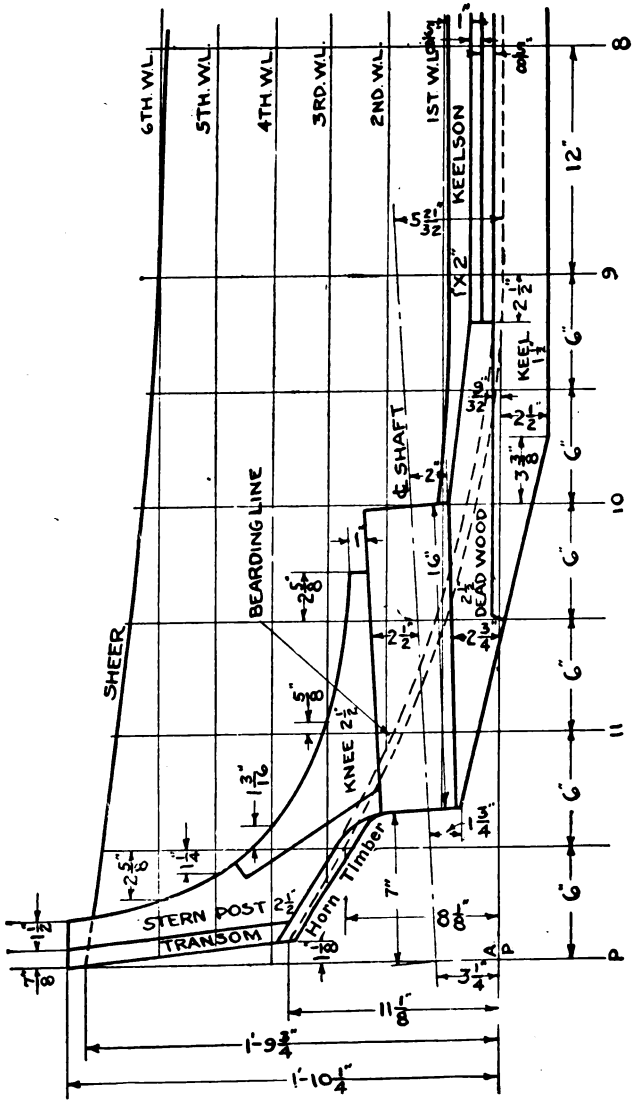

Figure 6.—Detail of Stern.

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the deck, and forms a receptacle for the after ends of the outside planking.

Stern Post Knee.—The stern post knee is placed in the angle formed by the keel and stern post.

Shaft Log.—The shaft log is the member of the stern through which the propeller shaft enters.

Deadwood.—The deadwood is the lowest member of the stern, run up to the height of the floor timbers, and on it the after ends of the keelson rest.

Horn Timber.—The horn timber protects the end of the stern post and covers up the end wood.

Transom.—The transom is the last main frame of the boat and is placed square with the stern post.

These members of the stem and stern are united to each other and to the fore and after ends of the keel by scarfs, bolted together.

STEM AND STERN MOULDS

It is necessary to make a separate mould, or pattern, for each member of the stem, Figure 7, and the stern, Figure 8, on which all construction lines are transferred from the mould loft floor. These moulds are needed in locating bearding and rabbet lines and locating various points such as water lines, etc., used in setting up the timbers and fairing the structure. Accuracy in making the moulds is very necessary, in order to insure the economical appropriation of timber and to facilitate the execution of the workmanship.

Picking Up the Lines.—A simple method of

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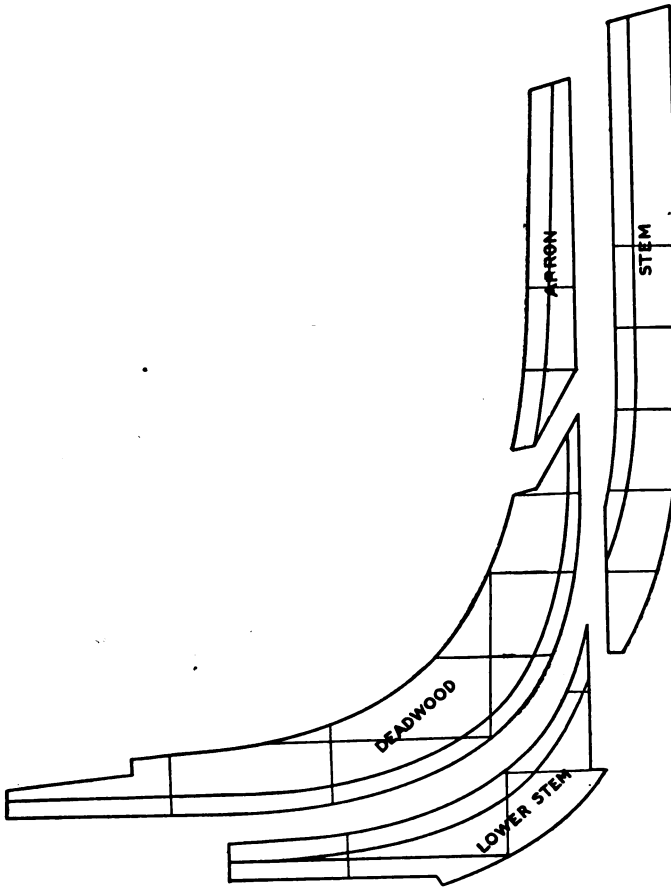

Figure 7.—Moulds for Stem.

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picking up the lines is shown in Figures 9 and 10. On the floor is shown the full size layout of the stem and stern construction shown in Figures 5 and 6.

Place a series of tacks with the heads resting

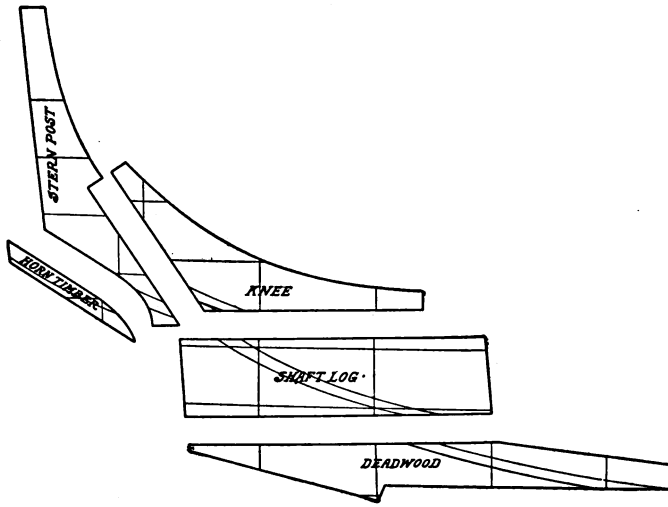

Figure 8.—Moulds for Stern.

on the required line, Figure 9. The heads of the tacks should be driven into the floor slightly, to prevent them from moving out of place.

Place a piece of stock wide enough to cover the member, with the grain of the wood running in the direction that will show the least amount of end wood (to prevent splitting when cut to shape). Give the mould several light taps with the hammer in the direction of the curve. The heads of the

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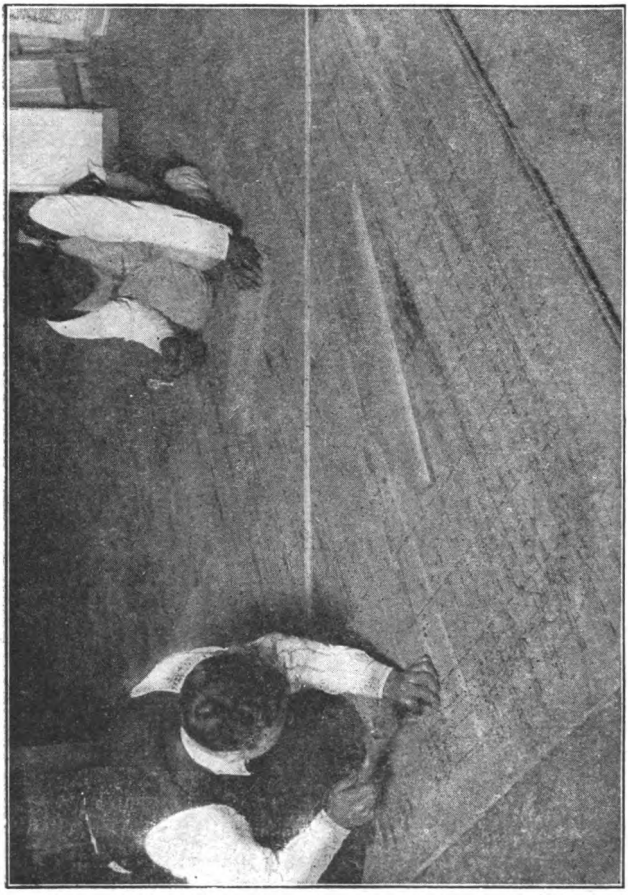

Figure 9.—Picking Up Lines from Mould Loft Floor.

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tacks will leave a mark into which a small brad can be driven and around which a batten can be bent. See Figure 10.

Saw the moulds on the band saw, leaving the lines full, and fair up by hand as shown in Figure 11, making a perfect fit of each piece.

Transfer the water lines and all construction lines from the floor to the mould, when the moulds will be ready for use.

The moulds are generally made of one-half inch pine. The stock for the stem, as shown in the detail, calls for 1½″ stock for all members except the apron, which is 2½″ material, and all members of the stern 2½″ stock, excepting the horn timber, which is 1½″ thick.

Cutting Out the Stock.—Apply the moulds to the stock to be used in the construction of the boat, and cut out the stock on the band saw, leaving the lines full for fairing up. If the moulds have been accurately shaped and fitted, the stock to be used can be lined up to these moulds and fitted without much trouble. They can now be riveted or bolted together.

RABBETING

It is usual and proper to cut the rabbet, or recess in the stem and stern to receive the ends of the planking, before raising them. The *bearding line,* or line formed by the curved surface of the vessel's planking with the stem, keel, and stern post, and the rabbet, or outside line of the planking, are

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Figure 10.—Bending Battens and Lining-in.

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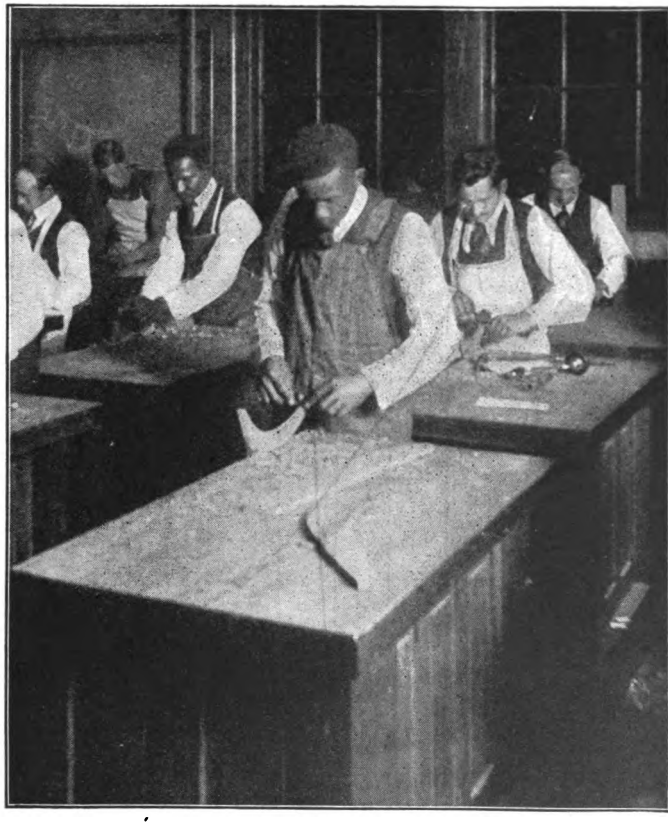

Figure 11.—Fairing Up Moulds.

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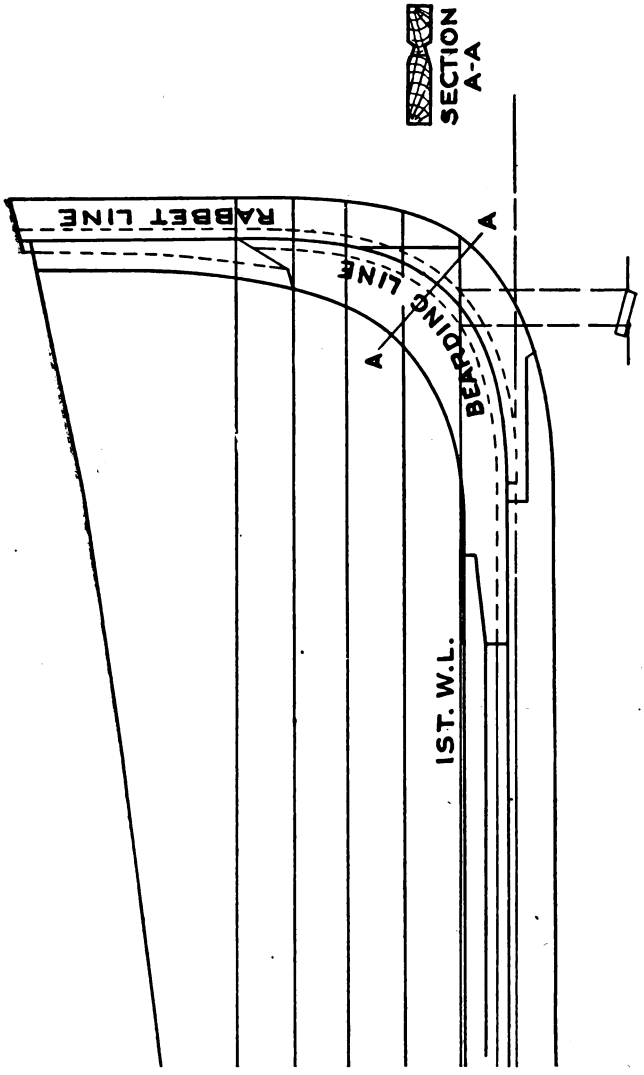

Figure 12.—Section Through Stem Showing the Development of Rabbet.

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transferred from the moulds to the stem and stern, and the rabbet is cut in with a chisel.

A section through the stem is shown in Figure 12 and a full-size detail of the rabbet is shown in Figure 13, the line *A-B*, Figure 13, representing the bearding line, and the line *C-D* the rabbet line. *E-F* is the width of the rabbet on the first water line, as shown on the projection, Figure 12, and is

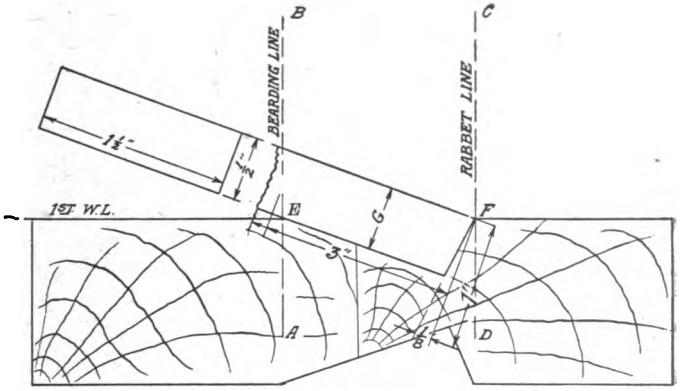

Figure 13.—Detail of Rabbet. (Section Through *A-A*, Figure 12.)

formed by the intersection of the bearding, rabbet, and first water lines.

Make a template or mould the thickness of the planking, as shown at *G*, about 1½″ wide and 3″ long, depending upon the size of the rabbet to be cut. Bevel one end as shown, about ⅛″ in 1″. Begin chiseling at the rabbet line to the bevel of the mould, and cut from the bearding line until the mould rests in the rabbet, Figure 14. The

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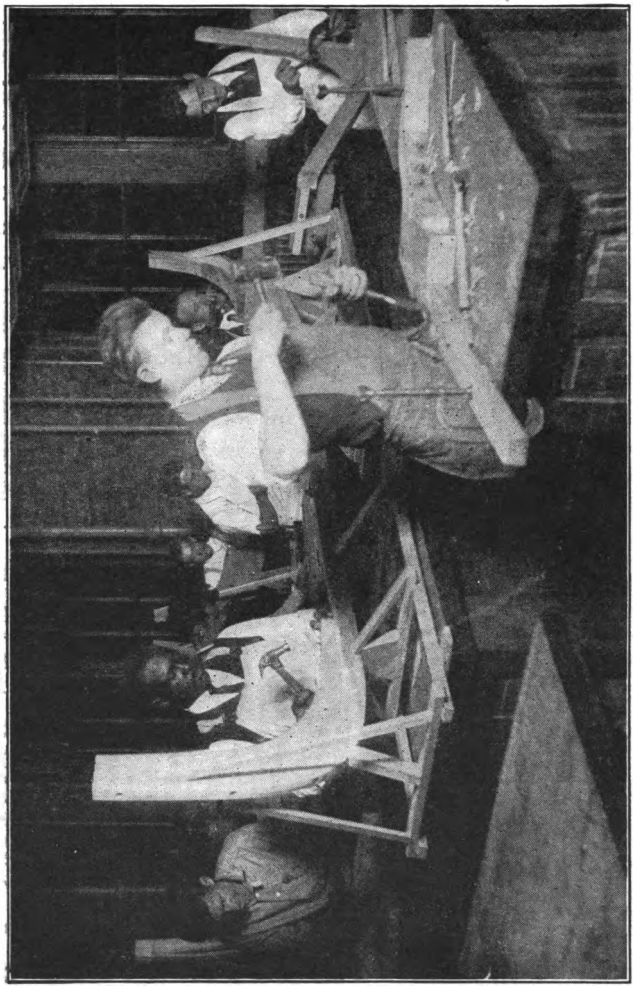

Figure 14.—Erecting Stem and Stern and Cutting Rabbets.

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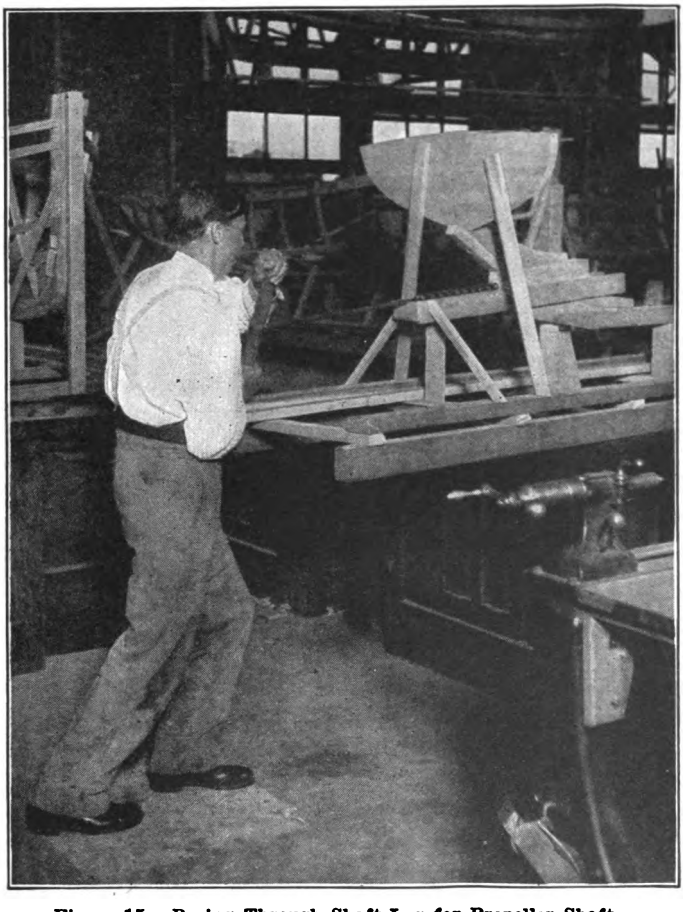

Figure 15.—Boring Through Shaft Log for Propeller Shaft.

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mould being the same thickness as the planking, the outside edge must intersect at *F*, or on the rabbet line.

Stopwaters.—The stopwaters, or round pieces of wood or dowels, are driven in at all seams running inboard, to render the vessel watertight.

KEEL

The keel, forming as it does the lower boundary of the longitudinal section, is spoken of as the backbone of the vessel. The pieces are obtained in as long lengths as possible, varying in size according to the size of the vessel.

The several pieces forming the keel are joined together by lock scarfs and also scarfed to the stem and stern, bolted and riveted together. A chalk line is run from the center of the stem and stern for the purpose of lining them up with the center of the keel.

The rabbet extends along the keel to receive the edge of the first strake of planking, or garboard strake. Station lines are marked upon the top of the keel, giving the location of the various frames. See Figure 14.

Shaft Log.—As soon as the stem and stern are plumbed and united to the keel, the opening for the propeller shaft should be bored through the shaft log, Figure 15. The line of the shaft is laid out from the mould. The bit is held in position as shown in the illustration to insure the proper direction.

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CHAPTER III

FUTTOCKS AND FRAMES

The futtocks, commonly called the *ribs* of the vessel, are the curved or crooked timbers giving the shape, to which the planking is fastened. Two futtocks united, right and left hand, constitute a *frame.*

FUTTOCK MOULDS

A mould should be made of each futtock of a different shape. Futtock moulds forward are shown in Figure 16. Futtock moulds aft are shown in Figure 17.

The method of picking up the lines from the mould loft floor is similar to the one described for picking up the lines of the stem and stern construction.

Another method is shown in Figure 18, using a flexible steel template. This template can be bent to any shape and is held in position by winged nut screws on the outside. Adjusting the template to the required shape on the mould loft floor, and fastening the screws, the template can be taken up and used in lining the stock to be cut.

The shape of the futtocks is taken from the body

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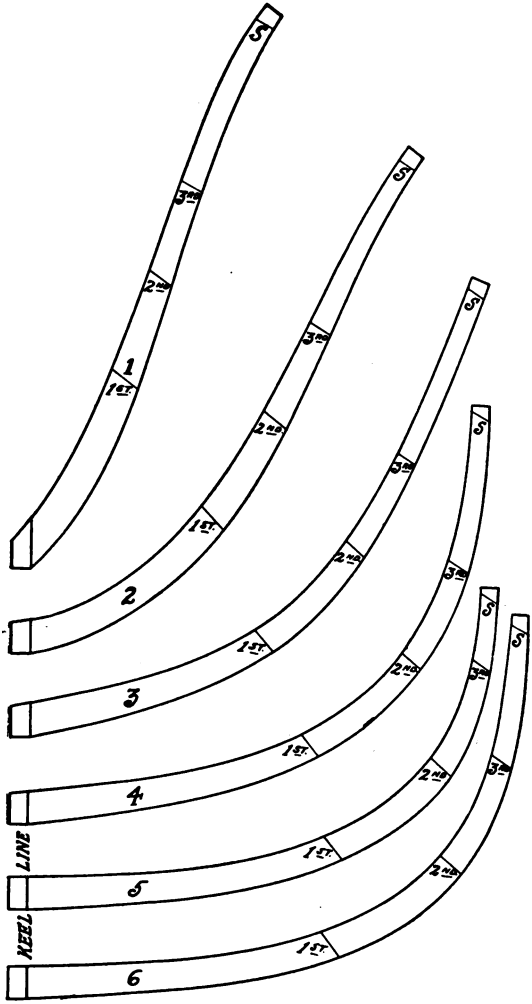

Figure 16.—Futtock Moulds Forward.

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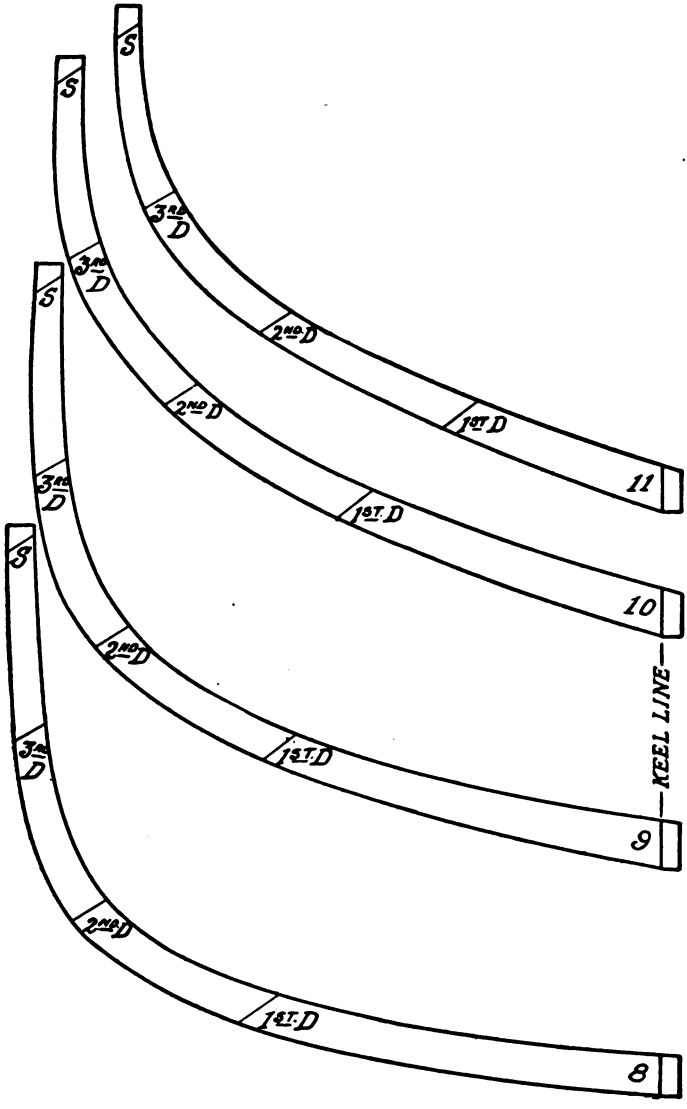

Figure 17.—Futtock Moulds Aft.

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plan, Figure 3. These lines give the outside lines of the frames. The width of the frames will depend largely upon the size and the demands to be made upon the vessel.

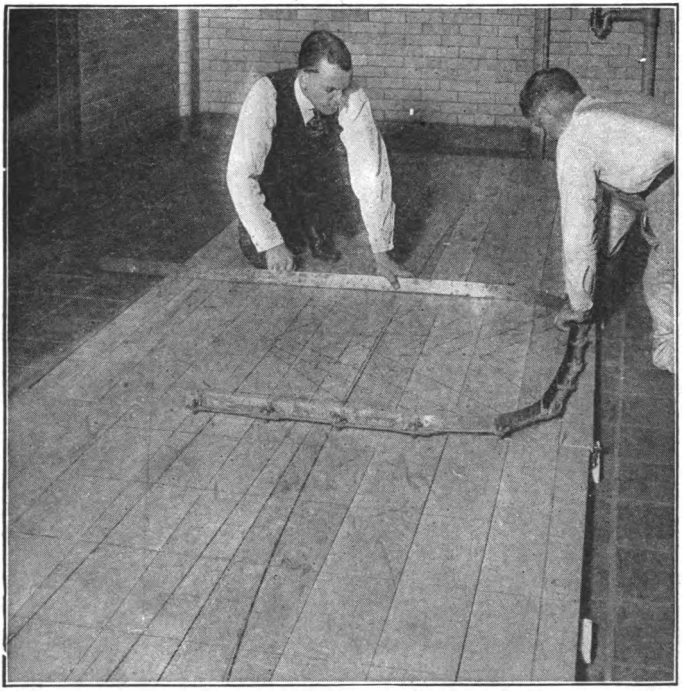

Figure 18.—Picking Up Lines from Mould Loft Floor with a Flexible Steel Template.

Cut the moulds full of the line to allow for fairing up, finishing the mould by hand. Each mould is numbered so it can readily be placed in its proper location.

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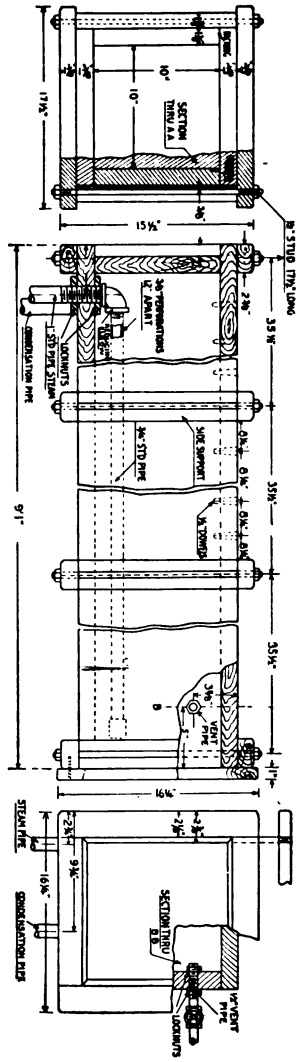

Figure 19.—Details of Steam Box.

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The sheer, diagonal, and keel lines are transferred from the floor to the moulds. These lines will be needed in lining up and setting the frames, and for locating the beveling spots and running the ribbands.

Surmarks.—The marks on the moulds showing

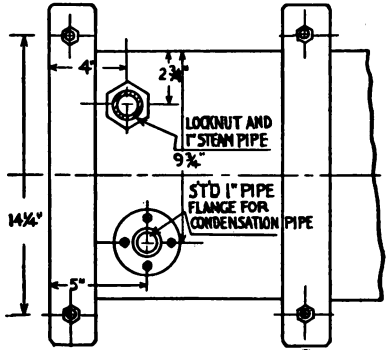

Figure 20.—Pipe Details of Steam Box.

the intermediate bevel stations, or where the diagonal lines cross the futtocks, are called *surmarks.*

STEAM BOX

The futtocks, ends of ribbands, and planking will need to be steamed in order to bend them to the required shape. The size of the steam box required is dependent upon the size of the timbers and planking to be bent.

Details of a steam box are shown in Figures 19, 20, 21 and 22. The dimensions can be varied, either enlarged or made smaller, to meet a special need.

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The box is made of cypress with butted joints and calked seams. Cleats continue around all four sides, bolted together.

The steam enters at one end and runs through a perforated pipe the entire length of the box, which distributes the steam and gives an even temperature throughout. At the front end a small

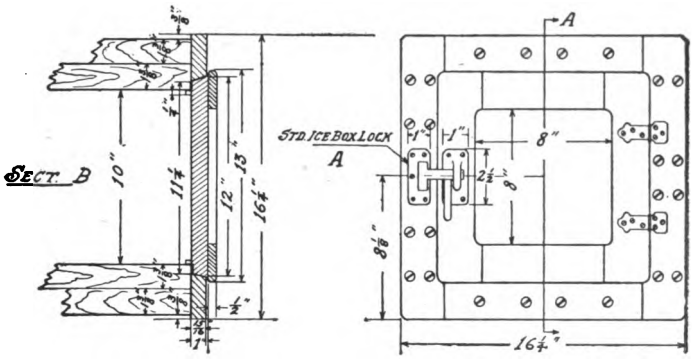

Figure 21.—Detail of Door of Steam Box.

vent pipe takes off the surplus steam and leads it out doors. At the far end there is an outlet for the condensation, leading to a water seal trap, shown in Figure 22. The water lying in the trap prevents the steam from escaping. The condensation can be drained into a pail or connected with the sewer if desired.

If the steam box is located out of doors, the condensation will take care of itself, as it can run off into the earth and the steam can escape and pass

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off in the atmosphere. If the steam box is located indoors, some provision of this kind should be

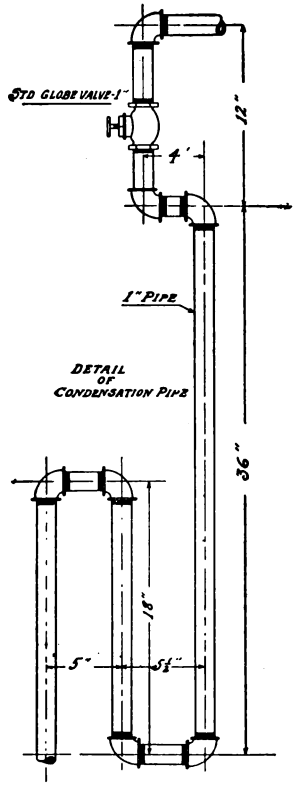

Figure 22.—Condensation Pipe and Water Seal Trap of Steam Box.

made for taking care of the condensation and surplus steam.

Packing is placed in the rabbet of the door to

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make it tight, the door locking with an ice-box fastener.

STEAM BENDING

Special bending stock should be used. Green or unseasoned lumber bends more readily and is not so liable to split while being bent as seasoned stock is. It would be better to put the stock into a water bath for several hours or overnight before steaming it.

The stock should be thick enough to make two futtocks, and when removed from the form should be resawed, making right and left hand futtocks, which, when fastened together, make a complete frame. The futtocks being thicker at the heel, some material can be saved and the stock will bend easier if the timbers are tapered.

Experience is the best teacher as to the length of time required to steam a piece of stock ready for bending. The greener or wetter the stock, the shorter the time required. If the stock is left in the box too long, the life is taken out of the timber and it becomes very brittle and breaks; while, on the other hand, if not left in the steam box long enough, the timber will also break.

STEAM BENDING FORM

A bending form is shown in Figure 23. The shape of the form should be made from the inside line of the moulds, and an extra allowance made for shaping and fitting, as well as for some spring in the timber when removed from the form. In

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other words, the form should be made to a quicker sweep than the moulds.

When the stock is ready to be bent, one piece is removed at a time from the steam box and a thin sheet of strap iron is nailed on the back of the timber, to give support to it while being bent and to insure a fairer bend.

As soon as this strap iron is fastened, one end is inserted under the bar, as shown in the illustration, and held in position by a wedge. One man bends the timber around the form and another man pulls it into place with a clamp.

The timber will retain the heat for some time, so there is nothing to be gained in forcing it to the breaking point.

As the timber is bent around the form, clamps are applied at intervals to give added support to the stock while bending. The end of the timber is held in place by a hook, which catches over an iron pipe extending the full width of the form. This can be seen in the lower right-hand corner of the form (Figure 23).

The timbers should set a day before being removed from the form, when they can be resawed and planed to the required thickness. Line up the timbers from the moulds and number each one for ready identification.

DIAGONAL LINES

The diagonal lines are drawn in on the body plan, Figure 3, standing as nearly square as pos-

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sible to the frame lines. They are considered the most effectual toward fairing the body of the vessel, or making each portion of the vessel assimilate with the others. The diagonals are distinguished

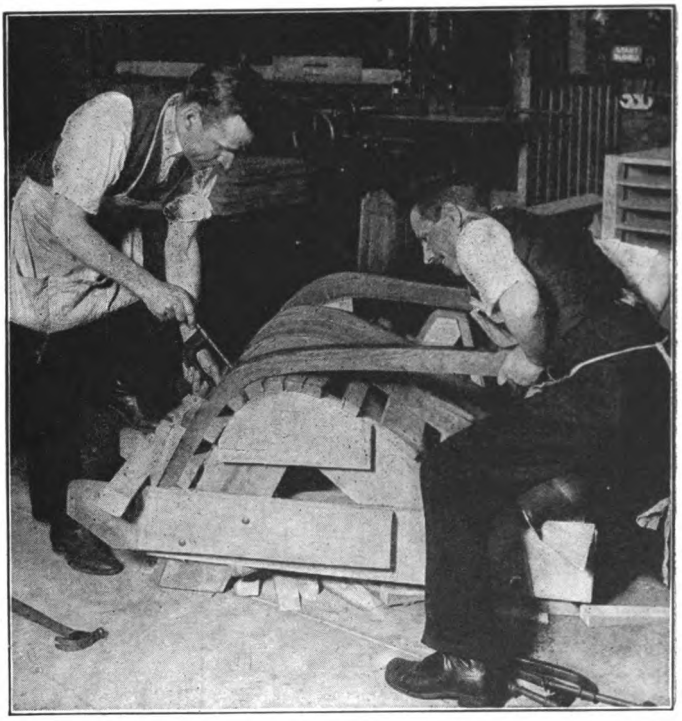

Figure 23.—Bending Timbers.

as "1st, 2nd, 3rd, etc., diagonals," and give the stations or surmarks of the ribbands, which are placed around the timbers to give support to the vessel while in frame.

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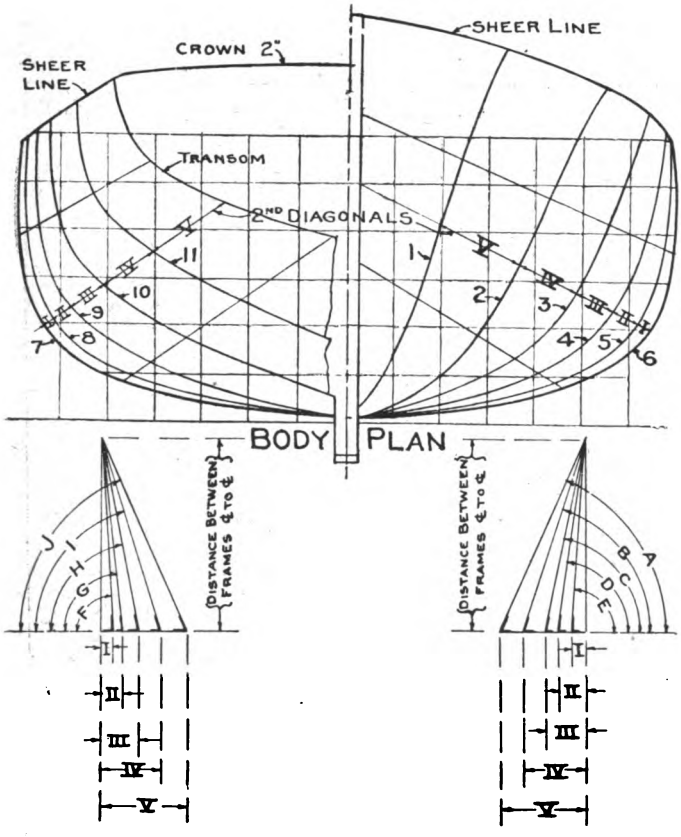

Figure 24.—Method of Developing Bevels on Diagonals.

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BEVELING FRAMES

The edges of the frames must be beveled, so that when the planking is bent around them they will fit tight at all points. These bevels are developed on the diagonal lines, as shown in Figure 24.

Draw two lines at right angles to each other. Point off a distance on the vertical line equal to the distance between frames, center to center. On the horizontal line point off from the intersection of these two lines the distance between frames 7 and 8 on the second diagonal, then the distance between frames 8 and 9, the distance between frames 9 and 10, the distance between frames 10 and 11 and the distance between frame 11 and the transom.

All measurements are to be taken on the second diagonal between frames, and all measured off from the intersection of the vertical and horizontal lines. Connect these points with the point on the vertical line, as shown in the illustration. Then bevel *F* is the bevel for frame 8, bevel *G* is the bevel for frame 9, bevel *H* is the bevel for frame 10, bevel *I* is the bevel for frame 11, and bevel *J* is the bevel for the transom. All bevels are developed on the second diagonal.

Likewise with the forward frames. Draw two lines at right angles to each other, as shown to the right in Fig. 24. On the vertical line measure off a distance equal to the distance between frames, center to center. On the horizontal line point off from the intersection of these two lines the distance

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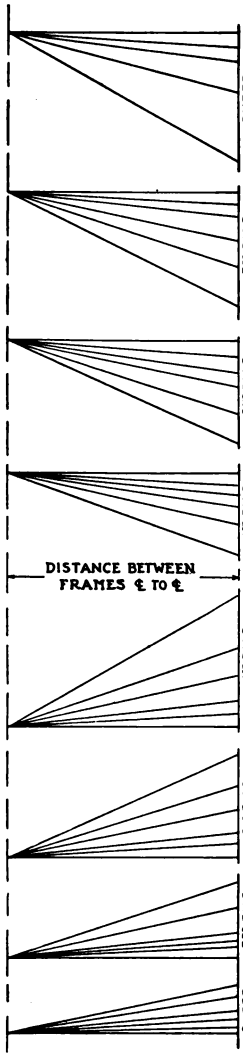

Figure 25.—Bevels on Each Diagonal.

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between frames 5 and 6 on the second diagonal; then the distance between frames 4 and 5, the distance between frames 3 and 4, the distance between frames 2 and 3, and the distance between frames 1 and 2.

All measurements are to be taken on the second diagonal between frames and all measured off from the intersection of the vertical and horizontal lines. Connect these points with the point on the vertical, as shown in the illustration. Then bevel *A* is the bevel for frame 1, bevel *B* is the bevel for frame 2, bevel *C* is the bevel for frame 3, bevel *D* is the bevel for frame 4, and bevel *E* is the bevel for frame 5. Frames 6 and 7 are amidship and are square.

Bevels are developed on each diagonal as shown in Figure 25. Therefore, in this particular boat, each frame has four bevels, namely, sheer, 1st, 2nd and 3rd diagonals, one fairing into the other.

BEVELING BOARD

The mould loftsman makes a beveling board, as shown in Figure 26, giving the various bevels. These bevels are taken from the developments, Figure 25. This saves time, referring to the mould loft, when laying out the frames, as it gives all the bevels needed for the entire vessel.

In many yards, and especially in ship work, the bevels are spoken of as *degrees,* and are so listed on the beveling board. This is for the information of the mechanic operating the band saw, as he tilts his saw one way or another to a desired angle,

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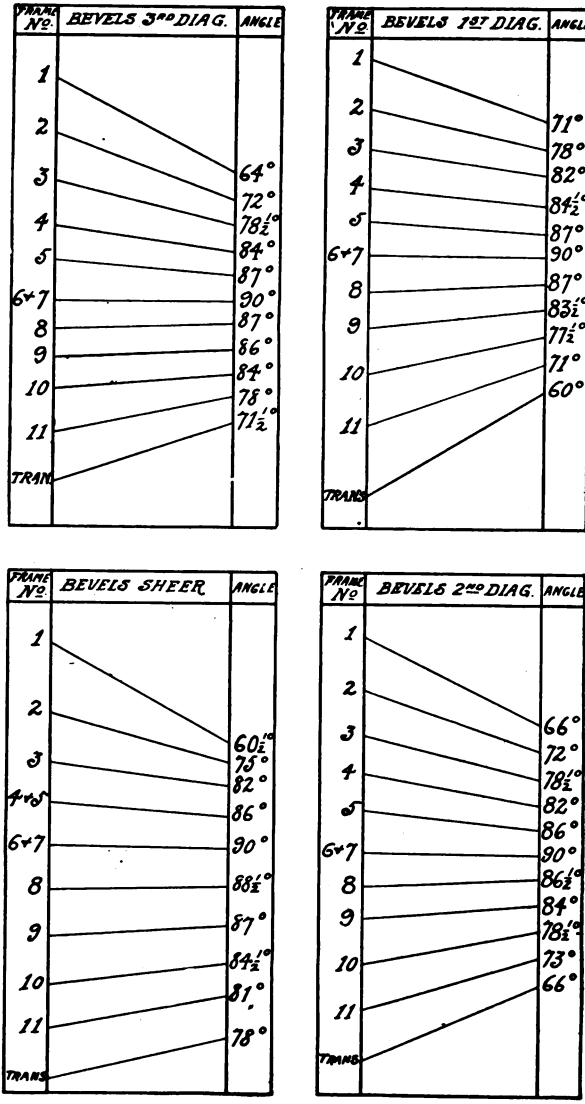

Figure 26.—Beveling Board.

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which is registered on the gauge of the machine, telling the operator the angle at which the machine is cutting. These degrees are marked on the frames at the given stations. The timbers are run through the band saw, changing the angle gradually as the stock nears each bevel. See Figure 27.

FRAME CONSTRUCTION

Several types of frame construction are shown in the illustrations. In Figure 28, false frames are first installed, ribbands are run, and the vessel faired up, after which the futtocks are bent and fitted to the ribbands.

Figure 29 shows a manufactured frame; that is, the futtocks are bent and then lined from the moulds and united with the floor timbers. The frames are then raised and plumbed, after which the ribbands are run and the vessel faired up.

Figure 30 shows a built-up frame; that is, a frame made of a number of pieces and double thickness of straight stock fastened together. The stock is roughed out, fitted and fastened together, and then lined from the moulds.

Figure 31 shows a strap frame boat. This is lighter construction. False frames are first installed, ribbands run, and the boat faired up. The frames are bent around a form, the ends tied together as shown in Figure 32, immediately removed from the form and sprung in position in the boat, while hot, and fastened to the ribbands.

Cross Spalls.—Cross spalls are long pieces of

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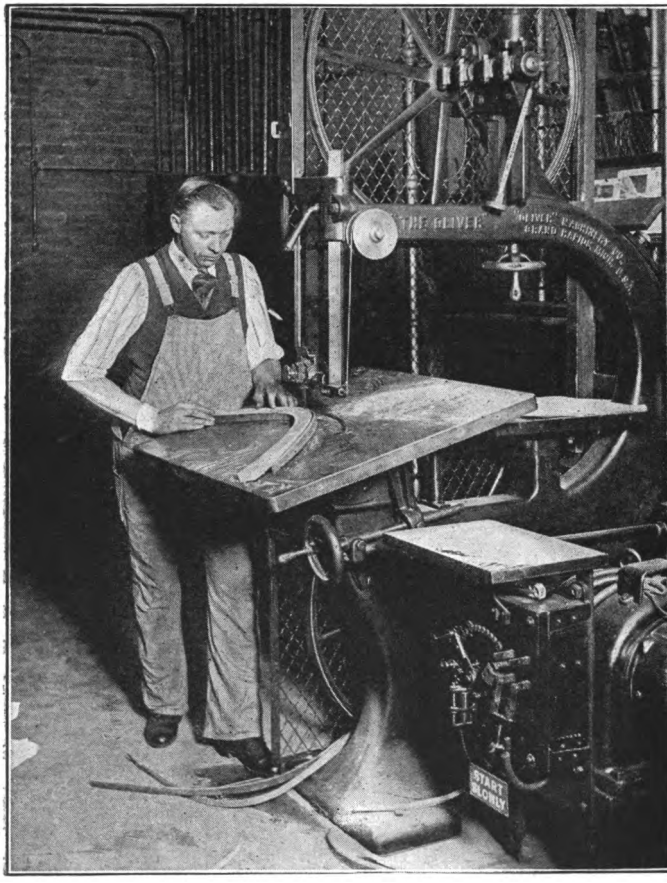

Figure 27.—Sawing Timbers.

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Figure 28.—Fitting Futtocks to Ribbands and Installing Frames.

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plank which have the breadth of the boat at particular stations marked on them, and unite the heads of the futtocks to the required width. These preserve the form of the boat while it remains in frame and until the beams are crossed. Note Figures 28 and 30.

Floor Timbers.—The heels of the futtocks are united with a floor timber as shown in Figure 28. The bottom edge is beveled to correspond to the beveling on the futtocks, the top edge remaining square. The two futtocks thus united form a *frame.*

RAISING FRAMES

The frames should be erected at right angles to the keel and perpendicular at their respective stations. A ribband is run at the first diagonal on both sides of the boat; square each frame from the keel and fasten to the ribband, then plumb every other frame, shoring them at the first diagonal ribband.

Install the sheer ribband and space off the timber heads to the same spacing as they are at the heels, after which all the ribbands may be run on.

Ribbands.—The ribbands are thin broad battens screwed fast to the frames at given stations on the square body, usually on the diagonal lines. See Figure 29.

Harpings.—The harpings are the continuations of the ribbands beyond the square frames. The ribbands and harpings are sometimes scarfed to

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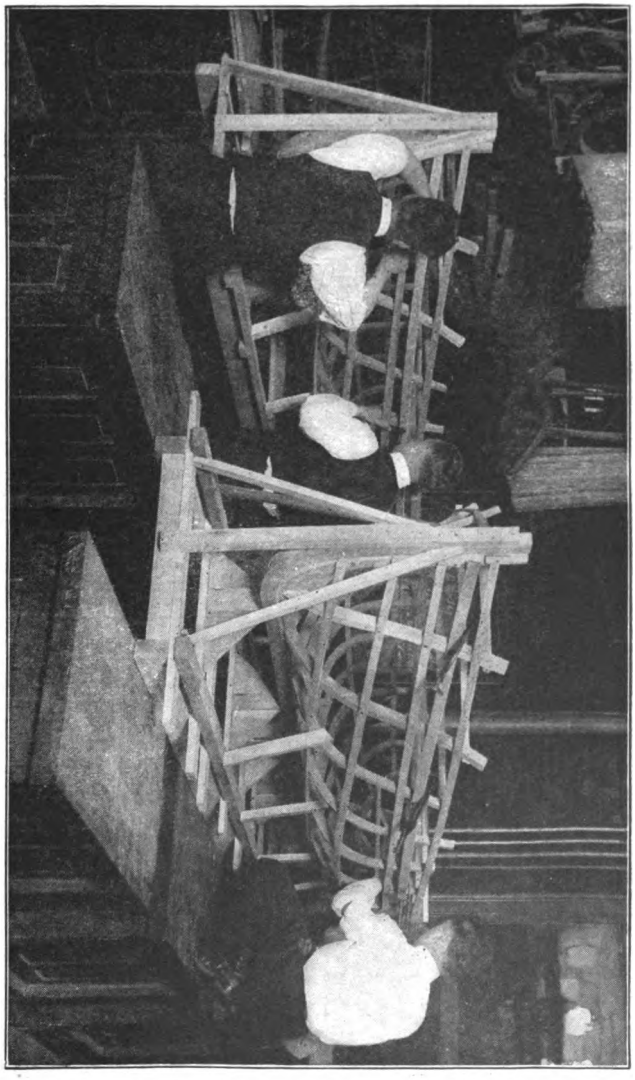

Figure 29.—Manufactured Frame Construction—Running Ribbands.

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Figure 30.—Built-up Frame Construction—Installing Sheer Strake.

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each other, but the connection is more usually kept up by one length of the ribband made to overrun the other.

FAIRING UP

A great deal depends upon the mechanical eye of the builder in *fairing up,* as a good design can easily be ruined at this stage of the construction. The lines of the boat should be regular, true, smooth, and flowing.

After the planking is installed, it will be impossible to cure any defects, and the graceful lines intended by the naval architect will be lost sight of. If the laying out and the workmanship have been careful up to this point, little difficulty should be experienced in fairing up.

PROJECTION OF DIAGONALS

Figure 33 shows the method of projecting the diagonals on the sheer plan from body plan. While these lines are not essential in fairing up, still they will help to show the position of the ribbands as they are bent around the frames.

Filling-in Pieces.—The filling-in pieces, usually 2″ wider than the top of the keel, are placed in the spaces between the frames, level with the floor timbers. They are fastened to the keel and form a rabbet to receive the garboard strake.

KEELSON

The keelson may be considered as an internal keel. It unites in one mass the keel, deadwood,

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Figure 31.—Strap Frame Construction.

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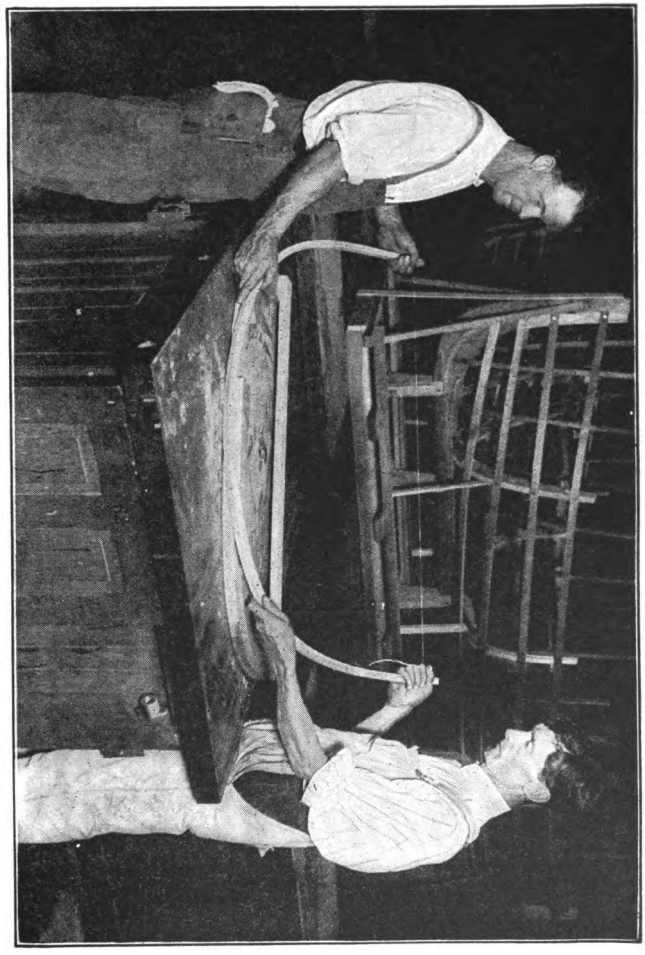

Figure 32.—Bending Frames for Strap Frame Boat.

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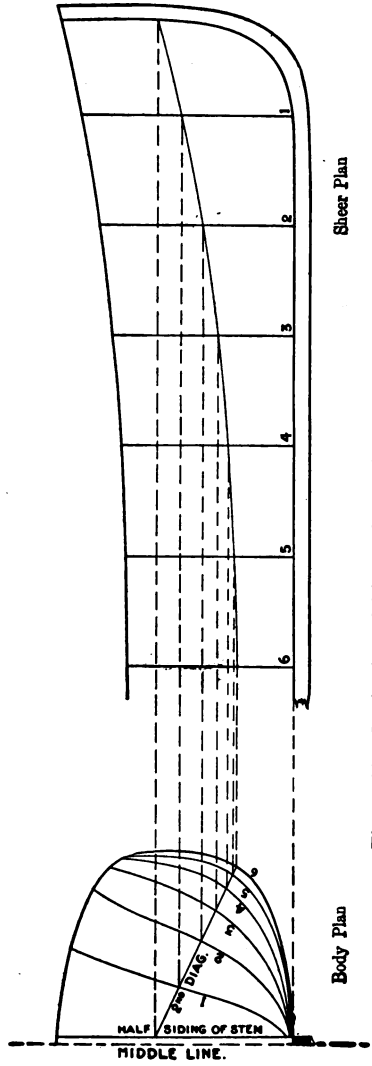

Figure 33.—Projection of Diagonals on Sheer Plan from the Body Plan.

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and floors, so that a compact union may be formed throughout the system. It is placed immediately above the keel, lying upon the upper part of the floors as far as they extend, and resting fore and aft against the deadwood. If the timber will permit, it should be put in in one length. If two pieces are scarfed together, care should be taken to have the scarfs properly shifted and clear of the keel scarfs.

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CHAPTER IV

OUTSIDE PLANKING

The outside planking, or skin, or sheathing, of a vessel terminates abaft below the transom, in the rabbet of the sternpost, and forward in the rabbet of the stem. The strakes are not parallel, but of such a breadth as may be required by the form of the place where they are situated and the circumference of the body at any given distances upon them; narrowing at some places and widening at others, according as the body requires the form of the edges to hang or "sny."

Strakes.—The principal strakes, or breadths of planking, are: *Binding, bilge, broad, garboard, sheer* or *upper, shutter,* and *lower* strakes.

The *binding strake* is the first strake to be installed, unless the horns of the frames are long enough to raise the sheer batten high enough to permit the installing of the sheer strake.

If the vessel is large enough, a strake can be worked near each ribband; and when on and fastened, the ribbands can be removed and several gangs of workmen can be employed advantageously in getting out and working the remainder of the plank required to fill up the openings.

Before commencing to plank a vessel, it is necessary to determine the number of strakes required

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and their widths at midship, as well as fore and aft. If the vessel is too long for the strakes to be obtained in one length, it will be necessary to run them in, in two or more lengths butted together. The position of these butts must be determined before laying out the first plank. They should be shifted, and in no case should they be less than four strakes apart.

To find the widths of strakes, bend a thin flat batten inside of the ribbands on the midship frame and obtain the girth or distance from the keel to the sheer line. Likewise fore and aft. Lay out on this batten the number of strakes required. The width of these strakes will depend upon the material available and the shape of the vessel. This is a matter of judgment, as there is no given rule for determining the width. The *garboard* plank should be the widest.

From the garboard to where the bilge turns, the strakes gradually diminish in width, so that the bilge and topsides are the narrowest and nearly uniform in width. The sheer strake is generally a little wider than the topsides, to allow for fastening the *moulding,* or *guard.*

SHEER STRAKE

The sheer batten gives the top edge of the sheer strake. The plank as it diminishes fore and aft must bring out the uniform longitudinal plank lines.

Assuming that the sheer strake is to be 4″ on the

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midship frame, 3¼″ at frame 1, and 2⅞″ at frame 11, the plank can be scaled as shown in Figure 34.

Scribe a circle with a radius equal to the width of the plank on the midship frame, and strike a center line as shown. Measure up, at right angles to the center line, a distance equal to the width of the plank at frame 1, until it cuts the circle as at *A*.

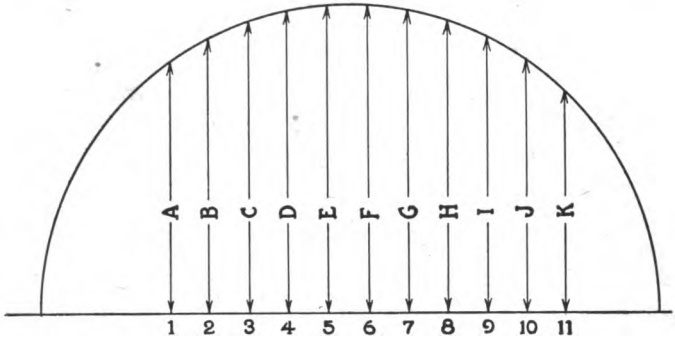

Figure 34.—Scaling for Sheer Strake.

Likewise measure up, at right angles to the center line, a distance equal to the width of the plank at frame 11 until it cuts the circle as at *K*.

Divide the distance between these two lines on the center line equally into as many spaces as there are frames, and lay off parallel lines as shown. Then the distance *A* is the width of the plank at frame 1, *B* width at frame 2, *C* width at frame 3, *D* width at frame 4, *E* width at frame 5, *F* width at frame 6, *G* width at frame 7, *H* width at frame 8, *I* width at frame 9, *J* width at frame 10, and *K* the width of planking at frame 11. These points will

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give a fair diminish for the lower edge of the sheer strake, and should be laid off on each frame from the sheer line, as shown in Figure 35.

BINDING STRAKE

The next problem is to cut the plank so that when bent around the frames it will fit without springing or bending it edgewise. In order to get the shape of the top edge of the binding strake, it will be necessary to take a spiling of the lower edge of the sheer strake. If material will permit, the binding strake is generally installed in one length.

SPILING

The spiling batten is a thin piece of stock 5″ or more in width and longer than the longest length of plank to be used. Secure the batten on to the frames with clamps, screws, or nails, temporarily, with its upper edge a little below the marks giving the lower edge of the sheer strake.

It is important that the batten follow the twist of the frames and lie flat against them, taking care not to spring it edgewise. See Figure 36. It is well to remember that the object is to have the batten occupy approximately the same position as the strake for which the spiling is taken.

Mark on the batten the center of the frames and take the spiling at these points, numbering each to correspond with the frame numbers, for ready identification. Spiling can be taken at any point, but reference marks must correspond on the spil-

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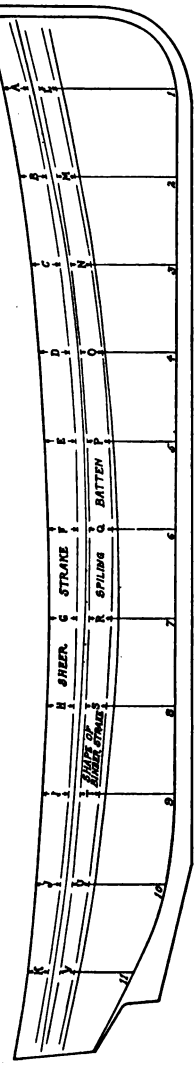

Figure 35.—Scaling and Spilling for Sheer and Binding Strakes.

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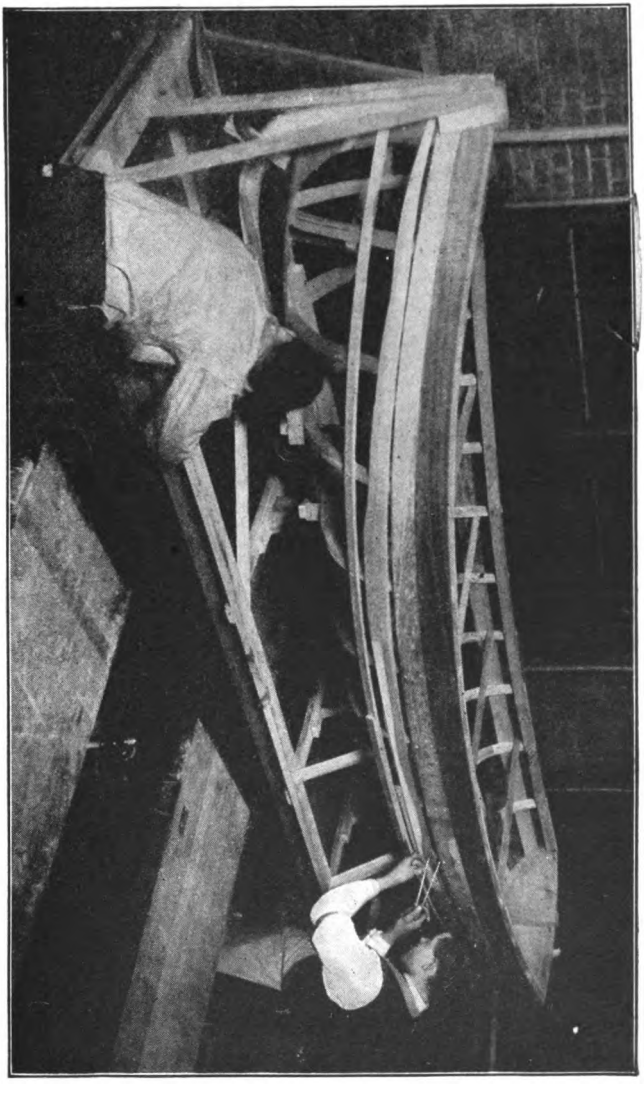

Figure 36.—Spiling for First Lower Strake.

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ing batten and the point from which the spiling was taken; otherwise it will be impossible to find the locations again, after removing the batten.

Set a pair of dividers to an opening a little greater than the widest gap between the spiling batten and the marks on the frames giving the lower edge of the sheer strake. With one leg of

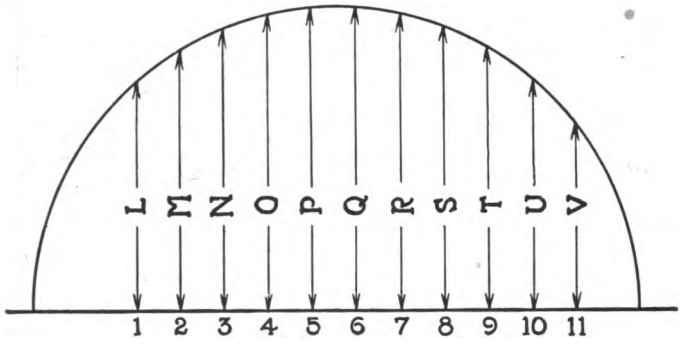

Figure 37.—Scaling for Binding Strake.

the dividers on this line, point off equal distances on the spiling batten, as shown in Figure 35. This gives the points for the upper edge of the binding strake.

Lay the spiling batten on the stock to be cut for the plank, mark the spiling spots, and transfer these points from the spiling batten to the plank to be cut.

This strake will be narrower than the sheer strake and it will be necessary to scale again for the lower edge, to get a fair diminish fore and aft.

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Scribe another circle, as shown in Figure 37, with a radius equal to the desired width of the plank on the midship frame, and strike a center line. Measure up, at right angles from the center line, a distance equal to the width of the plank at frame 1, until it cuts the circle as at *L*. Likewise measure up, at right angles to the center line, a distance equal to the width of the plank at frame 11, until it cuts the circle as at *V*.

Divide equally the distance between these two lines on the center line into as many spaces as there are frames, and lay off parallel lines as shown. Then the distance *L* is the width of the plank at frame 1, *M* width at frame 2, *N* width at frame 3, *O* width at frame 4, *P* width at frame 5, *Q* width at frame 6, *R* width at frame 7, *S* width at frame 8, *T* width at frame 9, *U* width at frame 10, *V* width at frame 11.

Lay off these distances from the spiling spots on the plank to be cut, as shown in Figure 35. Bend a batten through these points, which will give a fair diminish and the shape of the binding strake.

After the plank is sawed and fitted, a mate can be lined out for the other side of the boat before it is fastened.

GARBOARD STRAKE

After determining the width of the garboard strake at midship and fore and aft, run a ribband on the frames for the top edge of the garboard, which should look fair from all directions. It is

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important to have a proper diminish fore and aft, to avoid trouble in installing the *shutter* strake.

Bend a thin spiling batten around the frames to approximate the position of the garboard, and take a spiling for the lower edge, as previously described. Where the rabbet rounds up into the stem and stern, the spilings should be closer together and square out from the rabbet. Transfer these points from the spiling batten to the stock to be used for the plank, and bend a thin batten through these points. Measure up from the rabbet to the ribband or top edge of the garboard at each frame. Transfer these distances from corresponding positions on the plank, and bend a batten through these points, which give the shape of the garboard.

LOWER STRAKES

After the binding strake and garboard are installed, take the girth of the midship frame between these two planks and divide the distance into the number of planks desired to side in the remainder of the boat. Likewise take the girth on frame 1 and frame 11 and divide these distances by the number of planks in order to find the width of each plank fore and aft. A spiling must be taken for the top edge of each plank and the lower edge must be scaled to get a fair diminish fore and aft, bringing out as it does the parallel longitudinal lines of the boat.

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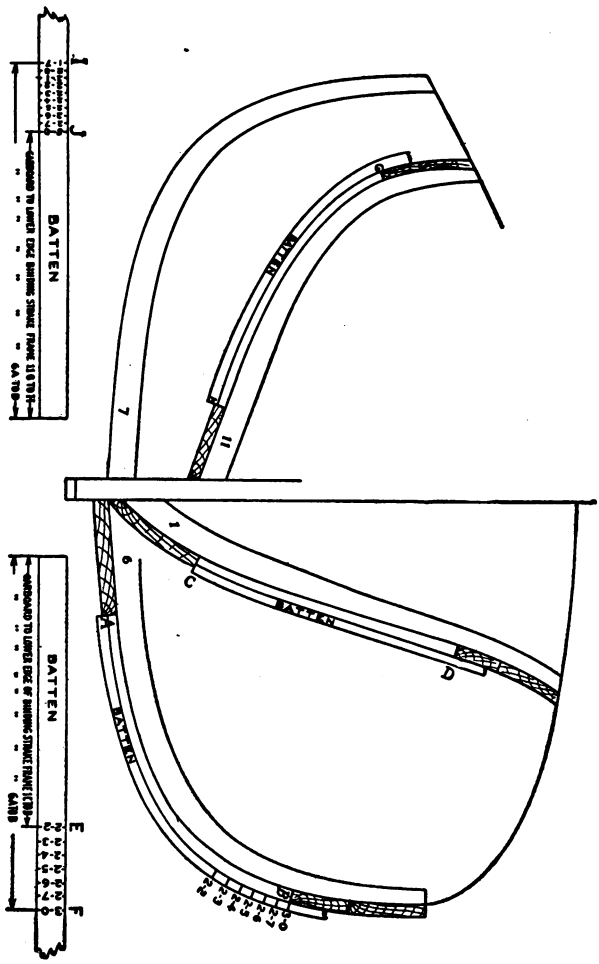

Figure 38.—Scaling for Lower Strakes.

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SCALING

Bend a thin batten around the midship frame to get the girth or distance between the garboard and binding strake as shown in Figure 38, *A-B*. Likewise take the girth between the same points on frame 1, *C-D*. Square these two points across the batten, *E-F*, and divide the space up into as many equal parts as there are eighths contained in the difference between the width of the plank at midship and the desired width at the stem.

Assume that the width of the plank is to be 3″ amidship and 2-2, or 2 2/8″, at the stem. The difference between 3″ and 2 2/8″ is 6 eighths; therefore, divide the difference in the girth of the midship frame, or frame 6, and the girth, or frame 1, into 6 equal parts, as shown in Figure 38, *E-F*. Mark the distance of the girth of the midship frame on the batten 3″, the distance of the girth of frame 1, 2-2. Each division is then numbered 2-3, 2-4, 2-5, 2-6, 2-7.

It will readily be seen that wherever this scale is applied with the lower edge of the batten always resting against the upper edge of the garboard, it immediately gives the width of the plank at that particular point. The width at each spiling station should be scaled and marked on the strake for ready reference. This gives a fair diminish for the plank on the forward end only.

The after end is then scaled in a similar manner, as shown in Figure 38. Take the width of the plank

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at midship, as previously described, as 3″, and assume that the width of the plank at frame 11 is to be 1-7 or 1-7/8″. The difference between 3″ and 1-7/8″ is 9 eighths. Divide the difference in the girth of the midship frame and the girth of frame 11 into 9 equal parts, as shown at *I-J*. Call the girth of the midship frame 3″ and the girth of frame 11 1-7/8″, and succeeding distances 2-0, 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7, 3-0. This immediately gives the width of the plank at that particular point. Scale each spiling station as before and mark on the strake for ready reference.

With the width thus determined, it is of course unnecessary to run ribbands on the frames, unless it appears that the strakes are not running fair, but a spiling must be taken for the upper edge of each plank. If the frames are curved, it may be necessary to hollow the inside of the planking to fit.

BEVELING FOR PLANKING

The planking should be beveled square from the diagonals. At the bottom edges of the seams the planks should be in contact throughout their length. After the planks are fitted, the outer edge should be beveled about 1/16″ in 1″, beveling from about the center of the plank. If the openings of the seams were of equal width throughout their depth between the planks, it would be impossible to make the calking sufficiently compact to resist the water.

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CALKING

Before beginning to calk, all seams should be jacked off and all high spots removed. Begin calk-

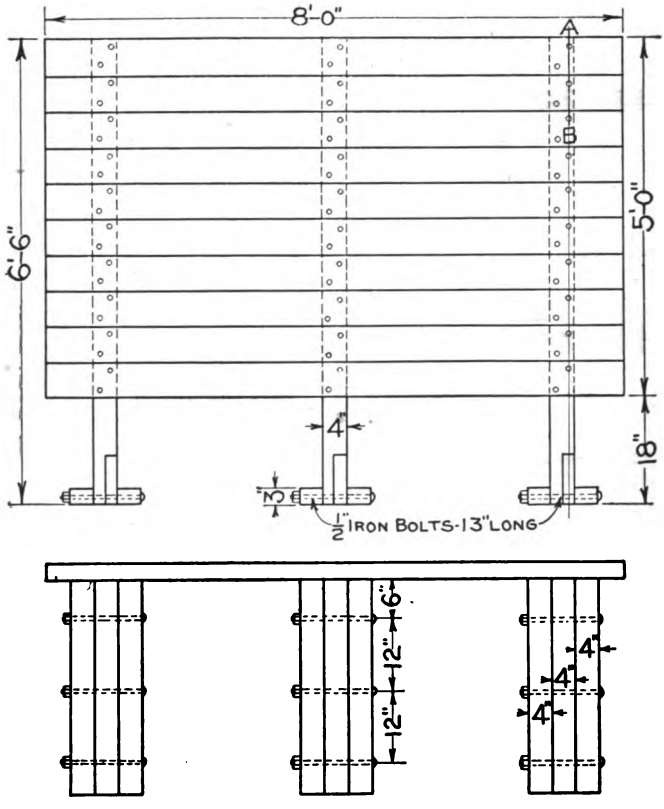

Figure 39.—Form for Practice Calking.

ing at one end and tuck a strand of cotton or oakum into the seam, then with a dumb iron gather the

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cotton or oakum into a small loop and drive it in; then another loop, and so on along the seam, varying the size of the loop to make just the right body of cotton or oakum to properly fill the seam.

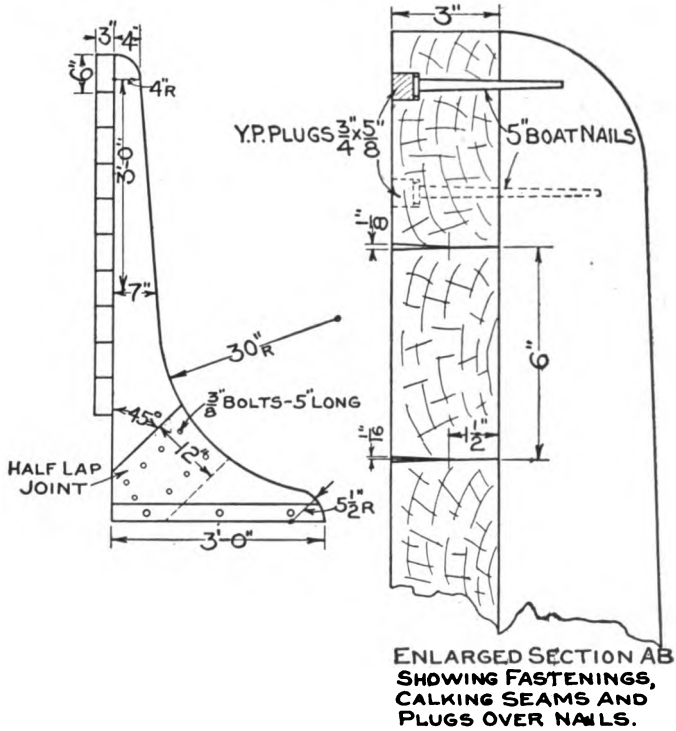

Figure 40.—Details of Form for Practice Calking.

Go over the seam again, using a calking iron, and drive the cotton or oakum home, so that room is left for the reception of the putty.

The tendency of the amateur is to drive the

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oakum into the planking instead of into the seam. This is very injurious and leads to leakage and to the rotting of the planks themselves.

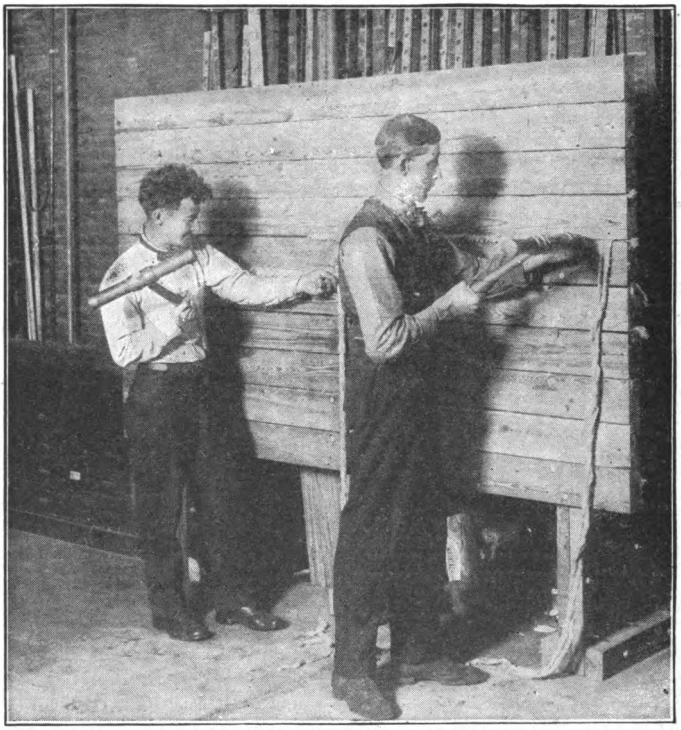

Figure 41.—Practice Calking

A suitable calking form for practice calking is shown in Figures 39-40. In Figure 41 two men are seen calking. Experience is the best teacher, and so it is worth while to begin practicing on a form

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of this kind. This form can be made collapsible, and the calking readily removed for recalking.

FINISHING

After calking, the seams are painted with a moderately thick paint, working it in well, so that it covers the calking material and serves as a binder for the putty. A special narrow brush, called a *seam brush,* is made for the purpose.

After the paint is dry, the planking should again be planed, using a smoothing plane, with the iron set very fine. It should then be sandpapered, first across the grain and then with the grain. All unfair places will be very conspicuous after painting, so it is very important that particular care be used at this time.

The seams are then filled with putty, flush with the outside, and again sandpapered, ready for the painter.

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CHAPTER V

SHIP CONSTRUCTION

MATERIALS AND PROCESSES

Practical shipbuilding requires a knowledge of the properties of the materials used in the construction of ships, and of the processes by which they are produced or prepared for use, so that they may be suitably selected for the services for which they were intended. It also requires a knowledge of the methods, means, and machinery by which, after delivery in the shipyards, the materials are brought to the required shape, erected in their proper relative position, connected together, and completed so as to form a structure which will fulfill the intentions of the designer.

There is an ever-increasing demand for rapid production. The revival of the wooden shipbuilding industry necessitates a vigorous and constant search for simplification of methods of work, for labor-saving and time-saving machinery, and for improved means of handling materials.

The shortage of skilled carpenters has caused engineering departments to design and construct new machines to take the place of men working on certain parts of a vessel, thus releasing a great many men for other work, where they can be used to better advantage.

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In previous chapters the methods of laying down the lines and developing bevels, scaling spiling, etc., have been taken up in detail. In the following chapters special attention is given to the methods of handling and fastening the large timbers used in ship construction.

Specifications.—The specifications are part and parcel of the drawings. They give a statement of all the particulars of the ship, including what is shown on the drawings as well as what cannot be shown on them. The quality of the materials to be used is described in detail and the scantlings, or dimensions, of the same are carefully recorded. It is also clearly stated how parts not manufactured by the shipbuilder are to be obtained.

Any omissions in the specifications, or in the drawings, the absence of which from the construction of the vessel would be weakening or detrimental, must be furnished by the builder.

The specifications are prepared by the naval architect, but this last clause serves as a check upon him. The decision, in all cases of doubt arising, rests with the architect.

SHEER PLAN

Figures 42, 43, 44, 45 and 46 give the sheer drawing for the standard 3500-ton cargo carrier. It is composed of three parts, mutually dependent upon each other, as follows:

Sheer Plan.—Figures 42 and 43 give the sheer

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plan, or outside form of the ship, stem and stern portions, respectively. The sheer plan consists of an elevation showing the longitudinal contour, the water lines or lines at which the vessel will float, and certain other lines parallel to this and equally spaced below it, which are also called water lines. A series of vertical lines equally spaced from stem to stern, called *square stations,* and certain other details are included in the sheer plan. The necessary tables of offsets are also given.

To lay off the sheer plan, Figures 42 and 43, first produce the base line and run the water lines in parallel to the base line spaced as shown on the plan. Then strike in the station lines at right angles to the base line as shown on the plan. To transfer the line, section E, on the sheer plan from the plan to the mould loft floor, refer to the table of offsets, heights above base and measure off the distances as given in this table, measuring up on each station line from the base line. On station 2, 39′ 7 2/8″; station 3, 16′ 4″; station 4, 1′ 6⅝″; station 5, 5⅞″; station 6, 5 6/8″; station 7, 5″; station 8, 5″; station 9, 5″; station 11, 5″; station 13, 5″; station 14, 5″; station 15, 5″; station 16, 5 4/8″; station 17, 1′ 6⅜″; station 18, 5′ 4 4/8″; station 19, 13′ 2⅞″; station 20, 21′ 3 2/8″; station 20½, 24′ 5″; station 21, 27′ 2″; station 21½, 29′ 11 2/8″; station 22, 36′ 6/8″. Drive a nail in at these points and bend a thin batten, as shown in Figure 4, so as to approximate as closely to these points as is consistent with absolute fairness and continuity. If

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the batten does not spring well to these points, it is best to pass the batten inside some and outside others in order to prevent great deviation from the design in either direction. Run a pencil along the face of the batten, producing the line on the floor, after which the batten can be removed and used again. The other section lines a, b, c, d, f, g, and h can all be transferred to the floor from the plan by measuring off the distances as given in the table of offsets for each respective line.

Half-breadth Plan.—Figures 44 and 45 give the half-breadth plan, stem and stern portions respectively, showing the form of the ship at the several water lines, supposing the hull to be cut by horizontal planes at the level of these water lines.

To lay off the half-breadth plan, Figures 44 and 45, first produce a line representing the center line and strike in the station and frame lines as shown on the plan. To transfer the water line marked 6′ 0″ on the half-breadth plan from the plan to the floor, refer to the table of offsets, half-breadths, and measure off the distances as given in this table, measuring off on each station line from the center line: On the stem 8″; station 2, 4′ 11″; station 3, 10′ 8″; station 4, 15′ 9″; station 5, 19′ 6⅜″; station 6, 21′ 8 2/8″; station 7, 22′ 5 6/8″; station 8, 22′ 7″; station 9, 22′ 7″; station 11, 22′ 7″; station 13, 22′ 7″; station 14, 22′ 7″; station 15, 22′ 2″; station 16, 20′ 10⅜″; station 17, 17′ 10 2/8″; station 18, 12′ 11⅝″; station 19, 7′ 6⅞″; station 20, 3′ 1⅝″ and station 20½, 1′ 5″.

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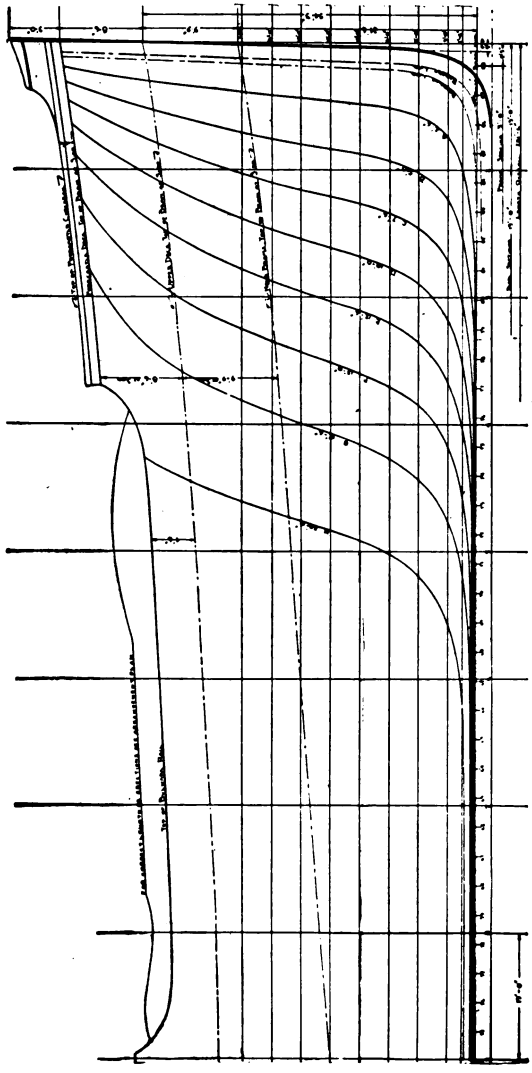

Figure 42.—Standard Wooden Steamship—Sheer Plan—Moulded Lines—Stem.

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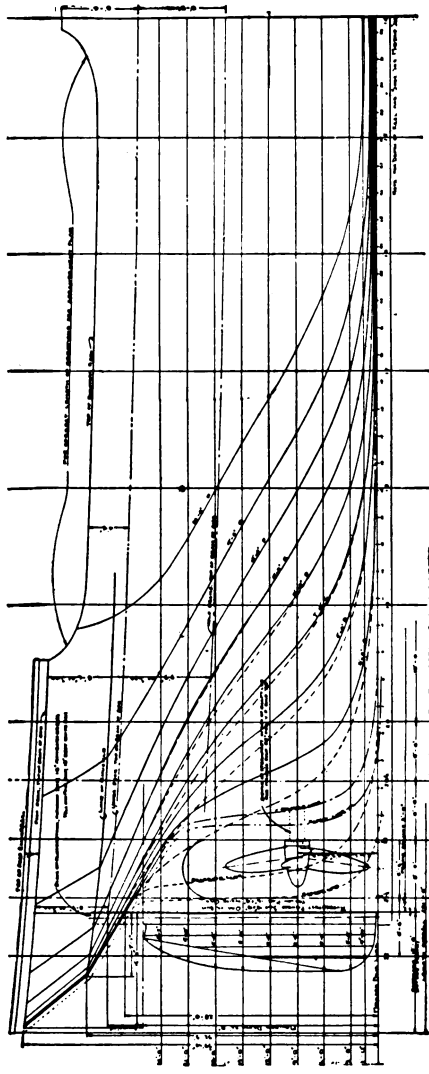

Figure 43.—Standard Wooden Steamship—Sheer Plan—Moulded Lines—Stern.

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TABLE OF OFFSETS, STANDARD WOODEN STEAMSHIP—HEIGHTS ABOVE BASE

		A	B	C	D	E	F	G	H	Upper dk.	P. B. & F.
	Stem.	.....	.....	.....	.....	.....	.....	.....	.....	34- 3-0	42- 9-0
	2	1- 4-2	5-11-6	2-3-1	34- 6-1	39- 7-2	.....	.....	.....	32- 2-3	40- 8-7
	3	6- 2-1	0- 5-7	1-6-7	4- 4-7	16- 4-0	30- 7-3	37-10-4	.....	30- 9-5	39- 3-4
	4	0- 1-7	0- 2-7	0-4-0	0- 8-1	1- 6-5	4- 2-0	17- 7-7	.....	29- 7-5	38- 1-4
	5	0- 1-4	0- 2-7	0-3-5	0- 4-7	0- 5-7	0-10-0	1-11-3	9-4-0	28- 7-7	.....
	6	0- 1-0	0- 2-5	0-3-3	0- 4-5	0- 5-6	0- 6-7	0- 8-7	1-9-5	27-10-2	.....
	7	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	27- 3-5	.....
	8	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 9-0	.....
	9	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 4-4	34-10-4
	11	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 1-0	34- 7-0
	13	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 1-0	34- 7-0
	14	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 7-2	1-2-2	26- 2-0	34- 8-0
	15	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-0	0- 6-0	0- 8-7	1-7-1	26- 3-7	34- 9-7
	16	0- 0-6	0- 2-3	0-3-1	0- 4-3	0- 5-4	0-10-3	1- 8-7	4-1-6	26- 6-7	.....
	17	0- 0-6	0- 2-3	0-4-0	0- 8-5	1- 6-3	3-10-7	5- 5-6	10-1-7	26-11-0	.....
	18	0- 2-1	0- 2-7	1-4-7	3- 0-0	5- 4-4	8- 8-0	12- 6-6	17-9-2	27- 3-3	.....
	19	0- 8-1	2- 2-5	5-9-7	9- 9-3	13- 2-7	16- 5-4	19-10-4	27-1-0	27- 9-0	.....
	20	6- 0-7	11-11-2	16-6-0	19- 1-0	21- 3-2	23- 8-5	27- 5-1	.....	28- 3-3	36- 9-3
	20½	14- 4-7	19- 3-0	21-0-7	22- 8-0	24- 5-0	26- 6-5	33- 9-7	.....	28- 7-7	37- 1-7
	21	23- 4-7	24- 0-7	24-9-7	25- 9-6	27- 2-0	29- 4-6	.....	.....	29- 1-2	37- 6-4
	21½	27- 2-6	27- 7-2	28-1-7	28-10-3	29-11-2	36- 6-7	.....	.....	29- 8-5	37-11-2
	22	31- 0-3	31- 2-2	31-6-3	32- 3-2	36- 0-6	.....	.....	.....	.....	38- 5-5
	Taffrail.	.....	.....	.....	.....	.....	.....	.....	.....	.....	39- 4-3
Twin screw	19	0- 6-2	2- 4-6	5-7-7	9- 6-4	13- 1-7	16- 5-4	19-10-4	27-1-0	.....	Knuckle.
	20	2- 8-5	10- 0-3	15-6-0	18- 7-1	21- 1-0	23- 6-5	27- 3-1	.....	.....	29- 8-7
	20½	7- 2-7	17- 1-7	20-5-0	22- 5-3	24- 3-4	26- 6-5	33- 9-7	.....	.....	30- 0-5
	21	19- 6-2	23- 2-0	24-6-6	25- 8-6	.....	.....	.....	.....	.....	30- 5-4
	21½	27- 2-0	.....	.....	.....	.....	.....	.....	.....	.....	31- 0-6
	22	30-11-1	.....	.....	.....	.....	.....	.....	.....	.....	31-10-7

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TABLE OF OFFSETS, STANDARD WOODEN STEAMSHIP—DIAGONALS

	No. 0	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Stem.											
2	9-1-6	8- 3-2	7-8-0	7- 2-7	6-10-7	6- 8-0	6- 6-0	6- 4-6	6- 0-5	5- 5-0	4- 3-0
3	15-2-6	14- 6-4	14-1-3	13- 8-4	13- 4-1	13- 1-6	12-10-7	12- 5-7	11- 5-0	9- 7-0	6- 5-0
4	19-1-5	18-10-0	18-7-7	18- 6-7	18- 5-2	18- 4-1	18- 0-0	17- 0-6	15- 0-2	11- 7-1	6- 9-2
5	21-3-2	21- 4-6	21-6-0	21- 8-3	21- 9-5	21-11-3	21- 9-0	20- 2-3	16-11-0	11-10-2	6- 9-2
6	22-3-3	22- 6-1	22-9-6	23- 2-2	23- 7-4	24- 1-4	23-11-2	21- 7-6	17- 1-1	11-10-2	6- 9-2
7	22-7-3	23- 0-0	23-3-7	23- 9-0	24- 2-5	24- 9-6	24-10-0	22- 1-1	17- 1-1	11-10-2	6- 9-2
8	22-8-2	23- 0-5	23-4-4	23- 9-7	24- 3-3	24-10-6	24-10-7	22- 1-2	17- 1-1	11-10-2	6- 9-2
9	22-8-2	23- 0-5	23-4-4	23- 9-7	24- 3-3	24-10-6	24-10-7	22- 1-2	17- 1-1	11-10-2	6- 9-2
11	22-8-2	23- 0-5	23-4-4	23- 9-7	24- 3-3	24-10-6	24-10-7	22- 1-2	17- 1-1	11-10-2	6- 9-2
13	22-8-2	23- 0-5	23-4-4	23- 9-7	24- 3-3	24-10-6	24-10-7	22- 1-2	17- 1-1	11-10-2	6- 9-2
14	22-8-2	23- 0-5	23-4-4	23- 9-7	24- 3-3	24-10-6	24-10-7	22- 1-2	17- 1-1	11-10-2	6- 9-2
15	22-7-3	22-11-3	23-2-7	23- 7-6	24- 0-3	24- 6-1	24- 4-2	21- 8-0	17- 1-1	11-10-2	6- 9-2
16	22-5-0	22- 9-2	23-0-2	23- 4-4	23- 7-7	23- 7-7	22- 8-3	20- 3-0	16- 8-5	11-10-2	6- 9-2
17	22-2-3	22- 5-3	22-7-2	22- 8-5	22- 4-7	21- 5-7	19-10-7	17- 9-3	15- 1-2	11- 5-7	6- 9-2
18	21-7-3	21-10-4	21-8-4	20-11-0	19- 6-4	17- 9-7	15-11-7	14- 2-2	12- 3-3	9- 8-5	6- 3-2
19	20-4-5	20- 2-7	19-3-5	17- 5-0	15- 1-5	13- 0-1	11- 2-4	9-10-2	8- 5-4	6-10-7	4-11-4
20	18-6-1	17- 5-0	15-1-4	11-11-2	9- 1-2	7- 1-0	5- 8-6	4-11-0	4- 3-2	3- 7-7	2-11-3
20½	17-4-1	15- 7-2	12-2-4	8- 3-3	5- 4-1	3- 6-2	2- 8-0	2- 4-2	2- 0-7	1-10-0	1- 6-6
21	16-0-1	13- 1-3	8-0-5	2- 1-7							
21½	14-2-3	8- 5-4	0-7-1								
22	9-3-0										
Taffrail.											
Twin Screw 19			19-3-5	17- 5-0	15- 1-7	13- 1-6	11- 3-7	9-11-6	8- 7-3	7- 1-4	5- 2-1
Twin Screw 20			15-1-5	12- 1-5	9- 6-7	7- 1-1	5- 8-7	5- 8-1	4-11-2	4- 2-7	3- 5-0
Twin Screw 20½			12-2-6	8-10-1	6- 4-3	4-10-0	3-11-3	3- 6-5	3- 1-7	2- 9-0	2- 4-6
Twin Screw 21			8-4-2	4- 7-0	2-10-0	2- 2-0	1-10-6	1- 9-2	1- 7-1	1-10-4	1- 5-1
Twin Screw 21½											
Twin Screw 22											

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TABLE OF OFFSETS, STANDARD WOODEN STEAMSHIP—HALF-BREADTHS

		1′–6″	3′–0″	6′–0″	9′–0″	12′–0″	15′–0″	18′–0″	21′–0″	24′–0″	Upper dk.	P. B. & F.
	Stem.	0- 8-0	0- 8-0	0- 8-0	0- 8-0	0- 8-0	0-8-0	0-8-0	0- 8-0	0- 8-0	0- 8-0	0- 8-0
	2	2- 7-4	3- 9-2	4-11-0	5- 5-0	5- 8-7	6-0-3	6-4-4	6- 9-3	7- 2-4	9- 1-7	13- 5-0
	3	7- 4-3	9- 4-0	10- 8-0	11- 4-7	11-10-3	12-3-3	12-8-7	13- 2-5	13- 8-4	15- 0-2	18- 2-3
	4	12- 3-1	14- 1-2	15- 9-0	16- 4-7	16-10-4	17-3-1	17-7-1	17-10-7	18- 2-6	18-10-3	20- 3-2
	5	16- 9-0	18- 4-0	19- 6-3	19-11-0	20- 2-4	20-4-0	20-7-1	20- 9-0	20-10-5	21- 0-1	.....
	6	19- 5-0	20- 9-6	21- 8-2	21-11-1	21-11-4	22-0-0	22-0-0	22- 0-2	22- 0-5	22- 0-7	.....
	7	20- 4-0	21- 9-0	22- 5-6	22- 6-3	22- 6-3	22-6-3	22-6-3	22- 6-3	22- 6-4	22- 6-4	.....
	8	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	.....
	9	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	.....
	11	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	.....
	13	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	.....
	14	20- 4-7	21-10-0	22- 7-0	22- 7-0	22- 7-0	22-7-0	22-7-0	22- 7-0	22- 7-0	22- 7-0	.....
	15	19- 8-0	21- 2-5	22- 2-0	22- 3-4	22- 4-1	22-4-5	22-5-1	22- 5-3	22- 5-7	22- 6-0	.....
	16	16- 8-4	18-11-7	20-10-3	21- 7-3	21-11-3	22-1-5	22-2-2	22- 2-7	22- 3-4	22- 3-5	.....
	17	12- 4-1	15- 1-0	17-10-2	19- 6-1	20- 7-4	21-3-4	21-8-1	21-10-3	21-11-5	22- 0-0	.....
	18	7- 5-0	9-11-5	12-11-5	15- 2-1	17- 1-5	18-9-2	20-0-7	20-10-5	21- 4-1	21- 5-2	.....
	19	3- 6-1	5- 2-5	7- 6-7	9- 4-7	11- 5-6	13-8-7	16-1-3	18- 1-7	19- 4-4	20- 0-3	20- 4-0
	20	1- 5-2	2- 1-1	3- 1-5	3-11-5	4-11-2	6-5-0	8-9-5	12- 2-1	15- 4-0	17-10-0	18-10-3
	20½	.....	0-11-0	1- 5-0	1- 9-4	2- 1-3	2-7-1	4-1-7	7- 2-2	11-11-0	16- 6-2	17-10-3
	21	.....	.....	.....	.....	.....	.....	.....	.....	4- 6-7	14-10-0	16- 7-7
	21½	.....	.....	.....	.....	.....	.....	.....	.....	.....	11-10-2	15- 2-7
	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13- 4-3
	Taffrail.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Twin screw	19	3-10-0	5- 6-3	7- 8-6	9- 6-3	11- 6-7	13-9-0	16-1-3	18- 1-7	19- 4-4	as above	Knuckle 18- 2-6
Twin screw	20	1-10-0	2- 7-0	3- 8-7	4- 7-6	5- 8-6	7-1-7	9-4-0	12- 4-4	15- 4-6	as above	Knuckle 18- 2-6
Twin screw	20½	1- 2-1	1- 6-7	2- 3-0	2- 8-7	3- 3-0	4-0-3	5-5-3	8- 1-5	11-11-0	.....	17- 0-6
Twin screw	21	.....	0-11-0	1- 1-7	1- 4-1	1- 6-2	1-8-3	2-1-0	3- 1-3	6- 3-7	.....	15- 9-0
Twin screw	21½	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	14- 0-5
Twin screw	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	9- 9-0

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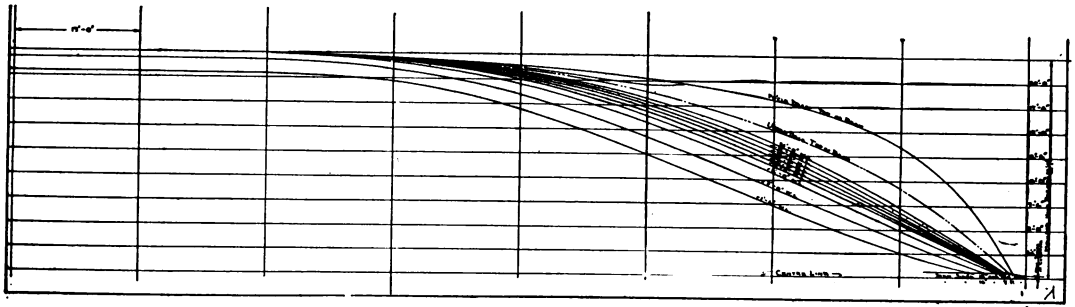

Figure 44.—Standard Wooden Steamship—Half-breadth Plan—Moulded Lines—Stem.

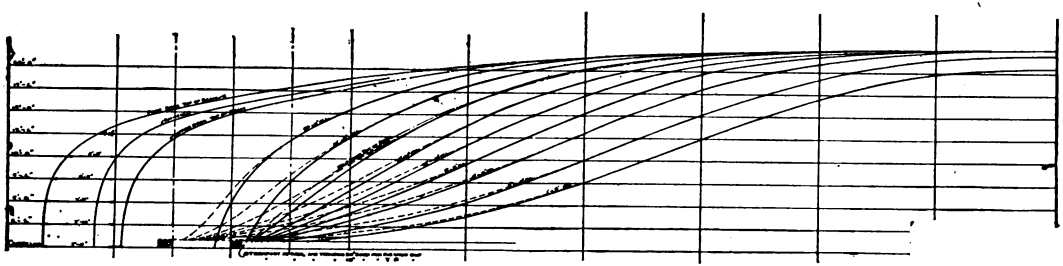

Figure 45.—Standard Wooden Steamship—Half-breadth Plan—Moulded Lines—Stern.

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Drive a nail in at these points as previously described, so as to approximate as closely to these points as is consistent with absolute fairness and continuity, bending the batten inside some and outside others in order to prevent great deviation from the design in either direction. Run a pencil along the face of the batten, producing a line on the floor, after which the batten can be removed and used again. The other water lines, 1′ 6″, 3′ 0″, 9′ 0″, 12′ 0″, 15′ 0″, 18′ 0″, 21′ 0″ and 24′ 0″, can all be transferred to the floor from the plan by measuring off the distances as given in the table of offsets for each respective line.

Body Plan.—Figure 46 shows the sectional form of the ship at the square stations, supposing the hull to be cut by transverse planes at these stations. The diagonal lines on which the bevels are developed as well as the curves of the frame lines outside the timbers at any point in the ship are also shown. Frame lines forward of the midship section are on the right of the center line; aft of the midship section on the left of the center line.

To Lay Off the Body Plan.—Figure 46, first produce the base line and run the water lines in parallel to the base line spaced as shown on the plan; the 1st water line being 1′ 6″ from the base line, 2nd water line 3′ 0″ from the base line, 3rd water line 6′ 0″ from the base line, 4th water line 9′ 0″ from the base line, 5th water line 12′ 0″ from the base line, 6th water line 15′ 0″ from the base line, 7th water line 18′ 0″ from the base line, 8th water

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line 21′ 0″ from the base line, 9th water line 24′ 0″ from the base line, upper deck 9′ 9″ above 9th water line, and the forecastle deck 8′ 6″ above upper deck. Then strike in the center line and run in the section lines parallel to the center line, spaced as shown on the plan, section line A being 2′ 6″ from the center line, section B, 5′ 0″ from the center line, section C, 7′ 6″, section D, 10′ 0″, section E, 12′ 6″, section F, 15′ 0″, section G, 17′ 6″, section H, 20′ 0″. To spot the points for the various frame lines, measure from the base line on the sheer plan on the frame desired the distance from the base line to where each section line crosses the frame station and transfer these distances on the corresponding section line on the body plan. For example, take frame 3 on the sheer plan and measure the distance from the base line to where section A cuts the frame station line, transfer this distance on section A on the body plan measuring up from the base line. Likewise measure the distance from the base line to where each section line cuts the frame 3 and transfer these distances on the corresponding section lines on the body plan. This gives a series of points in which a small nail may be driven and a thin batten bent through them and the frame line penned in. This will give the shape of frame 3. Each frame station must be developed in this manner. Sometimes the body plan is drawn over the sheer plan, making it easier to project these points. These points may be proven by measuring from the center line on the half-breadth

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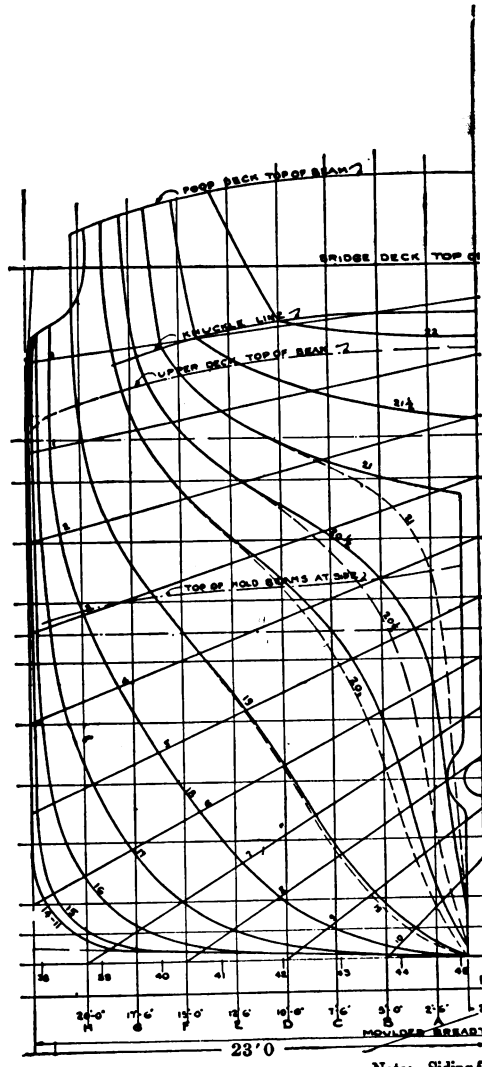

Note:—Siding for Fir

Figure 46.—Standard Wooden Steamship

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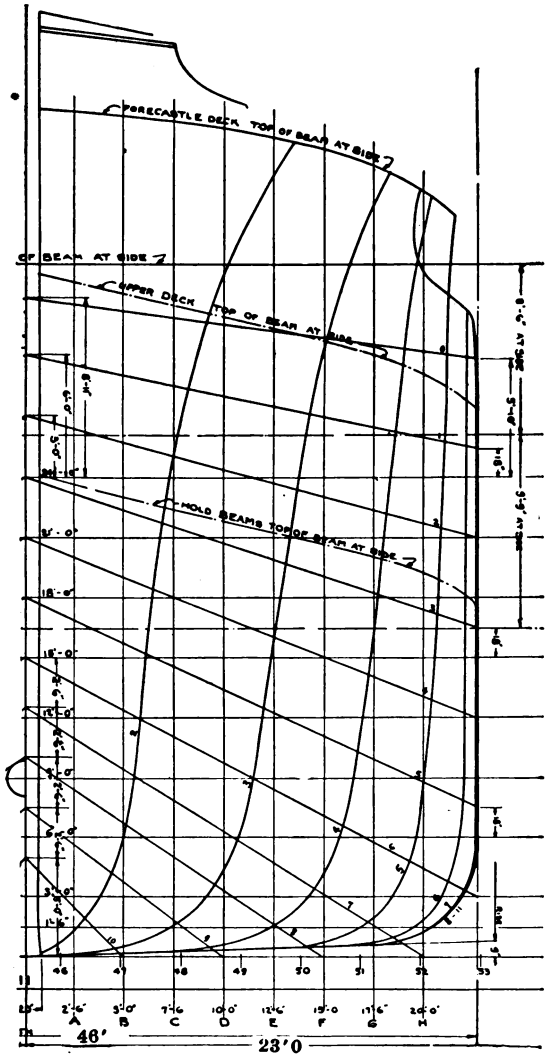

Wood 20″, for Y. P. 16″.

Moulded Lines—Body Plan.

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plan to where each water line cuts the frame stations and transfers these distances on the corresponding water lines on the body plan, measuring in from the center line. The points thus obtained should be the same as those taken from the sheer plan.

Diagonals.—To lay off the diagonal lines shown in the body plan, Figure 46, refer to the table of offsets and measure off the distances as listed in this table, measuring at right angles from the center line, making a point where these distances cut each frame station. This gives a series of points on each frame line through which the diagonal line may be drawn.

TABLES OF OFFSETS

Preliminary offsets of standard wooden steamships are given in the accompanying tables, for heights above base, diagonals and half-breadths, respectively. These tables exhibit the distances from a center or base line and are compiled by the architect to assist the mould loftsman in laying down the lines of the vessel full size on the floor and from which the shape of the moulds are taken. All offset figures in these tables are to be outside of the frame (inside of plank) and are listed in feet, inches and eighths.

Dimensions.—The dimensions of the standard steamship are as follows:

Length on deck.....281′–6″

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Length bet. perpendiculars..268′–0″
Breadth moulded ..... 45′–2″
Depth moulded at side..... 26′–0″
Designed load draft (full)... 23′–6″

Midship Construction Section.—Figures 47 to 52 show the structural arrangements of the ship and scantlings of the most important parts. This plan is not laid down full size on the floor. It is a detail drawing for the use of the workmen. It is a plan as of the whole of the ship developed at amidships and in such detail as to form a guide to the construction.

The midship construction section is shown in detail in Figure 47, while miscellaneous sections appear in Figures 48, 49, 50, 51 and 52.

Figure 48 shows a section from the bridge deck to top of the wheel house, including the boat deck and boat deck house.

Figure 49 is a section through the poop to above the poop deck.

Figure 50 shows the section through the engine foundation, looking forward. One-third of the engine holding-down bolts are put through to the bottom of the foundation keelsons. The remaining two-thirds of the holding-down fastenings are heavy lag-screw bolts.

Figure 51 is a section through the shaft tunnel, looking aft, and Figure 52 shows the section through the forecastle.

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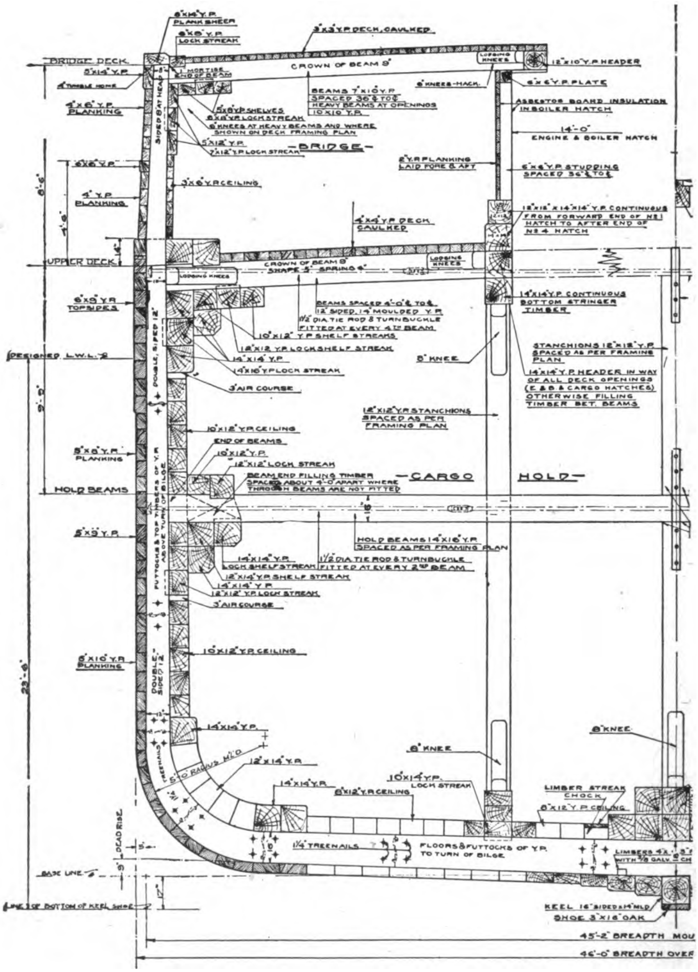
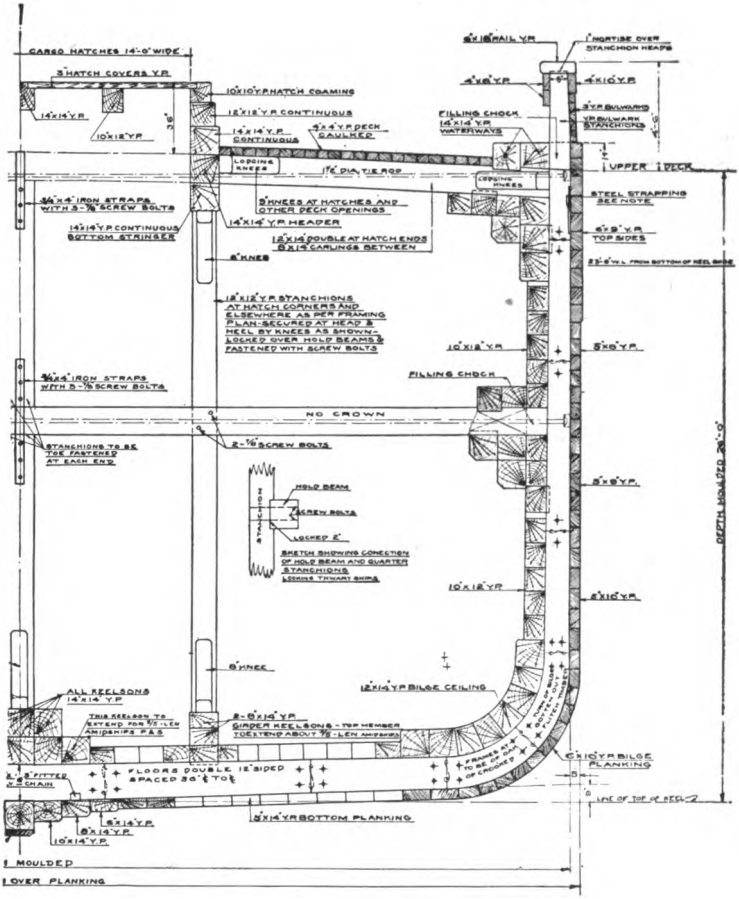


Figure 47.—Midship Section of



Standard Wooden Steamship.

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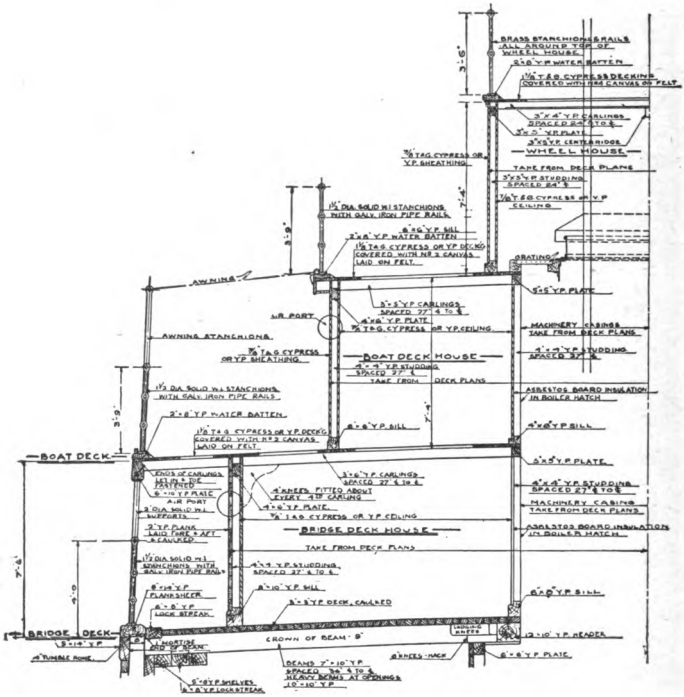

Figure 48.—Section from Bridge Deck to Top of Wheelhouse of Standard Wooden Steamship.

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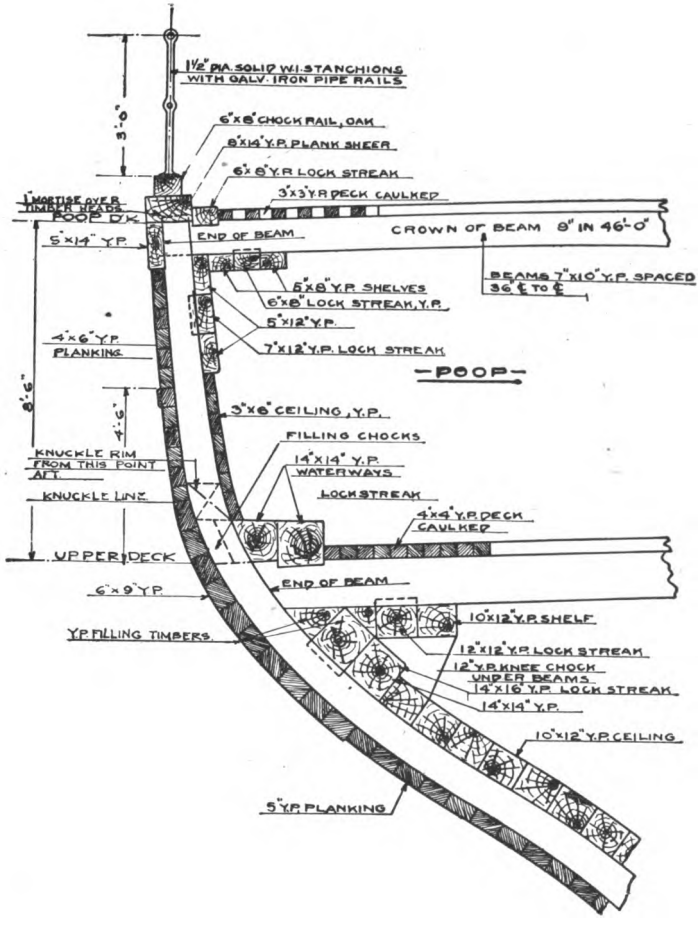

Figure 49.—Section Through Poop.

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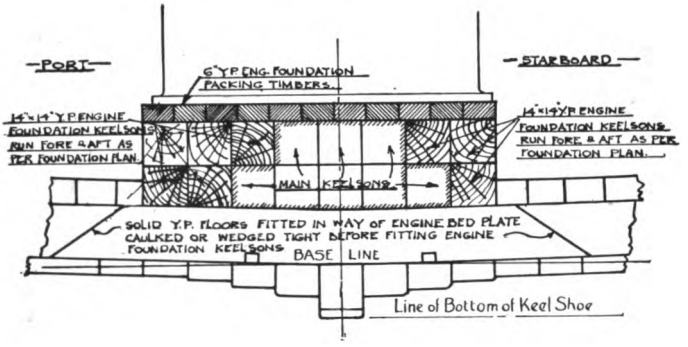

Figure 50.—Section Through Engine Foundation, Looking Forward.

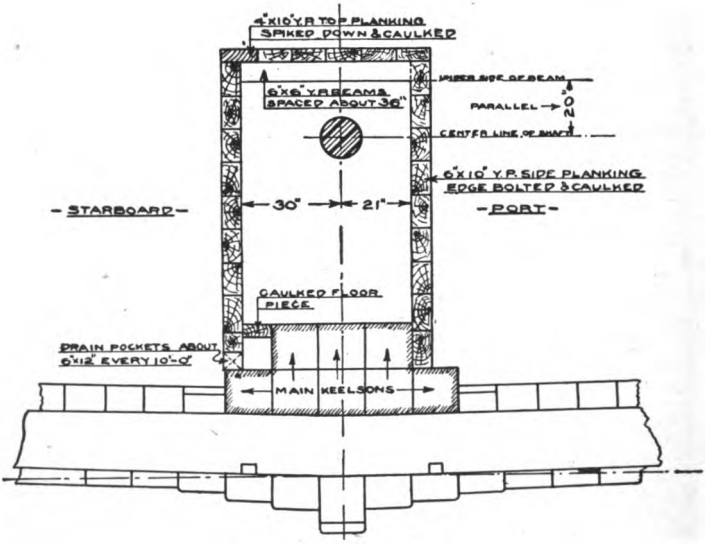

Figure 51.—Section Through Shaft Tunnel, Looking Aft.

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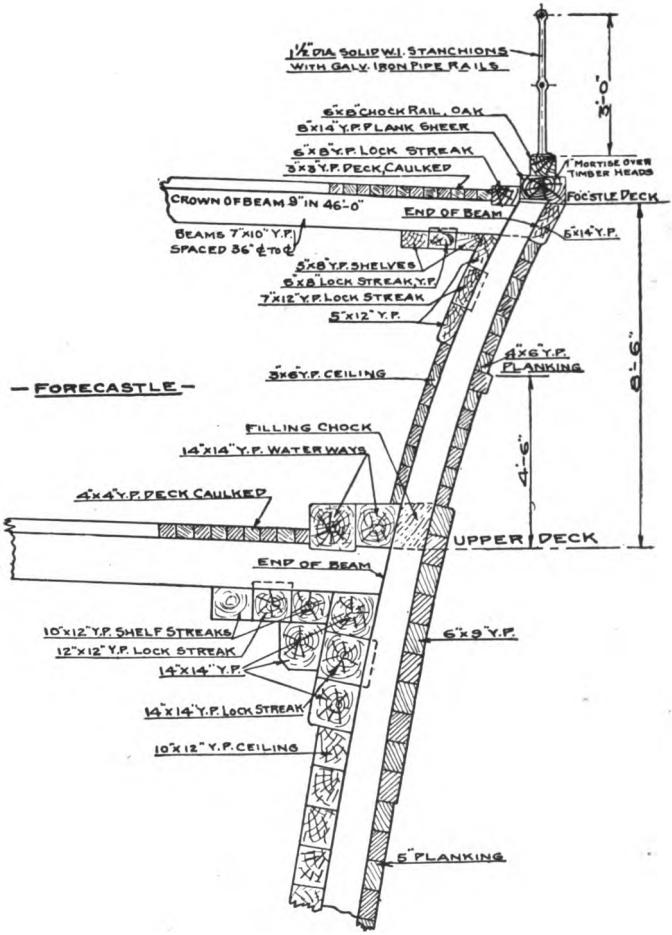

Figure 52.—Section Through the Forecastle.

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THE PROFILE AND PLANS

The profile and plans give all the internal arrangements of the vessel, the holds or spaces set apart for the cargo, the positions of the engine and boilers, the accommodations provided for the officers and crew and other principal fittings. These plans are shown in Figures 53 to 63 inclusive. An inboard profile of the ship is seen in Figure 53 and the arrangement of the decks and numerous other details appear in the remaining illustrations. Figure 54 shows details of the wheel house and navigating bridge and Figure 55 the top of the wheel house. The layout of the boat deck is seen in Figure 56 and the top of the gun house in Figure 57. Figure 58 shows the poop deck arrangement, and Figure 59 the bridge deck. The forecastle deck plan appears in Figure 60. Figure 61 shows a section through the engine room, looking forward, and Figure 62, a section through the boiler room looking aft. Figure 63 is a plan view at the dynamo flat and engineer's store room.

SCANTLING

The following are the scantlings, or dimensions, for various parts of the standard wooden steamship. These scantlings are all shown in their relative positions on the midship construction section, Figure 47:

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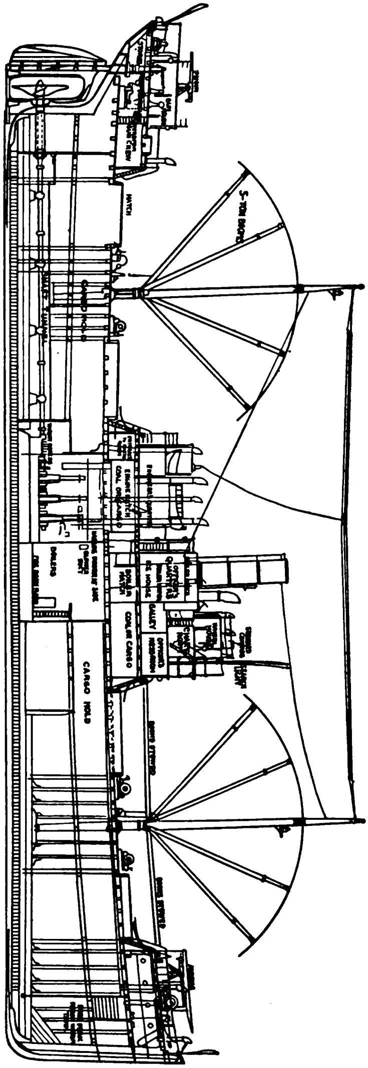

Figure 53.—Inboard Profile of Standard Wood Steamship for the U. S. Shipping Board.

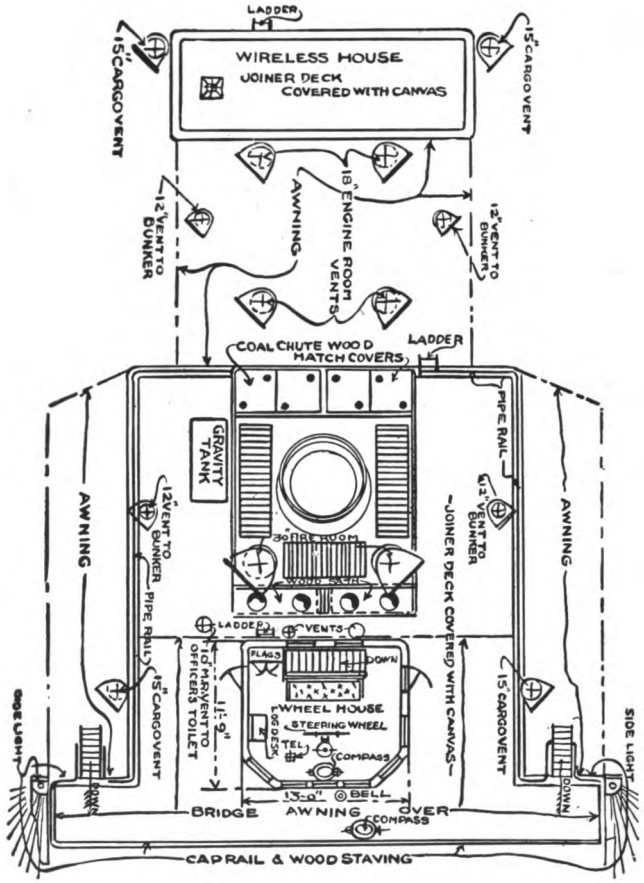

Figure 54.—Wheel House and Navigating Bridge

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Keel.—Sided 16″, moulded 14″, yellow pine.

Shoe.—Sided 3″, moulded 16″, white oak.

Stem.—Sided 16″, moulded 20″, yellow pine.

Apron.—Double 16″x16″, yellow pine.

Knightheads.—Sided 20″ and moulded same as frames, yellow pine.

Frames.—Sided 12″, moulded on keel 18″; at turn of bilge 16″; at top of bilge 12″; at upper deck 10″; at bridge, forecastle and poop deck 8″; and also at bulwark rail 8″. Double sawed of yellow pine.

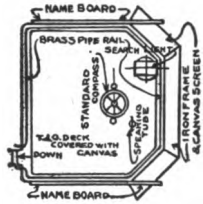

Figure 55.—Top of Wheel House.

Forward Deadwood and Knee.—Sided 16″, moulded 18″, yellow pine.

Outside and Inside Sternpost.—Sided 28″ way of shaft log, 16″ above keel, and at head moulded 24″, white oak.

Shaft Log.—14″x14″, built up in four pieces, white oak.

After Deadwood and Knee.—Sided 16″, moulded 18″, yellow pine.

Rudder Post.—Sided 16″, moulded 18″, white oak.

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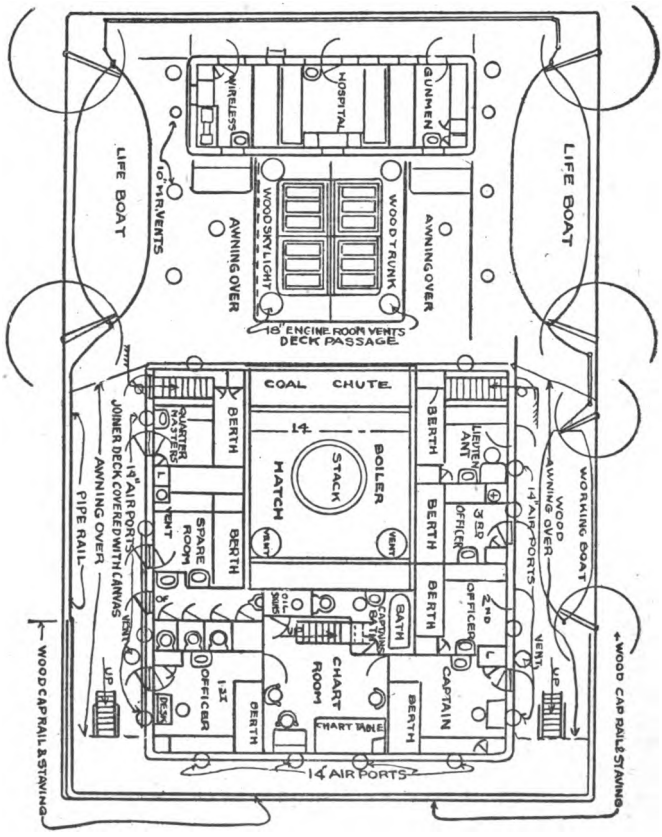

Figure 56.—Boat Deck, Standard Wood Steamship.

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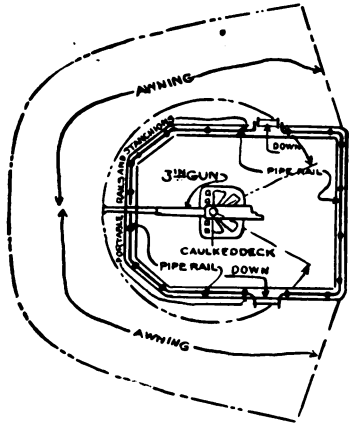

Figure 57.—Top of Gun House.

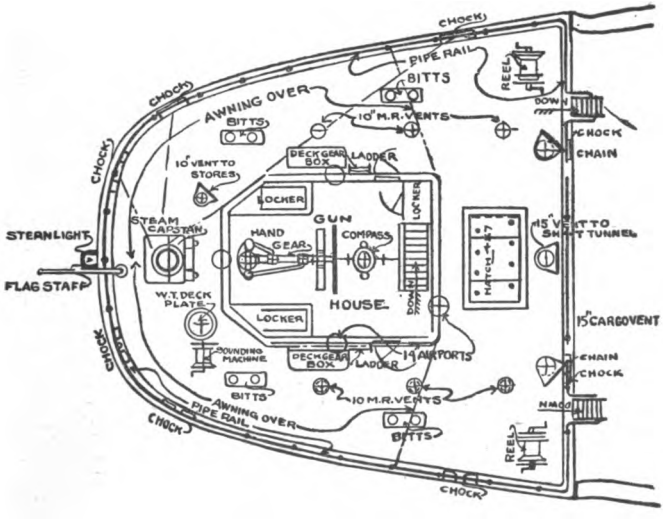

Figure 58.—Poop Deck.

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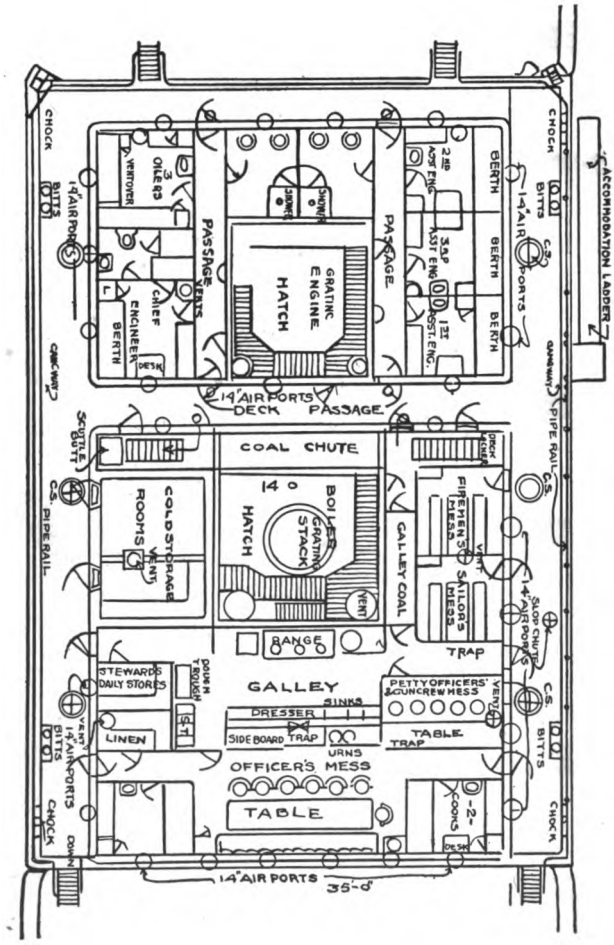

Figure 59.—Bridge Deck, Standard Wood Steamship.

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Horn Timbers.—Sided 12″, white oak.

Rudder Stock.—Finished 20″ in diameter, white oak.

Rudder Blade.—To be built-up of yellow pine tapered to 14″ after edge.

Main Keelsons.—Sided 14″, moulded 14″, yellow pine.

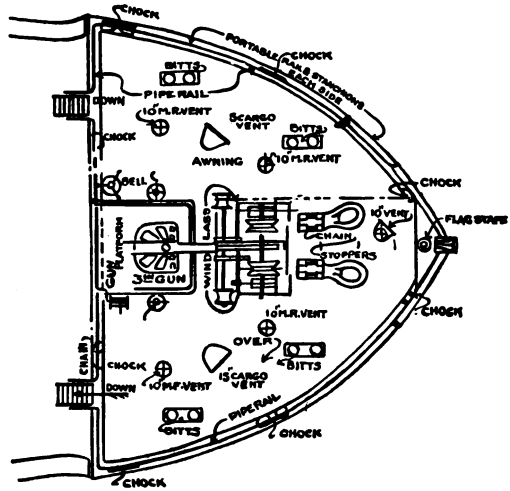

Figure 60.—Forecastle Deck.

Girder Keelsons.—First strake sided 10″, moulded 14″, second and third strake, sided 8″ and moulded 14″, yellow pine.

Bottom and Side Ceiling.—Bottom ceiling sided 8″, moulded, 12″, side ceiling, sided 10″, moulded 12″, yellow pine.

Bilge Ceiling.—Three strakes sided 14″, moulded 14″, five strakes sided 12″, moulded 14″, yellow pine.

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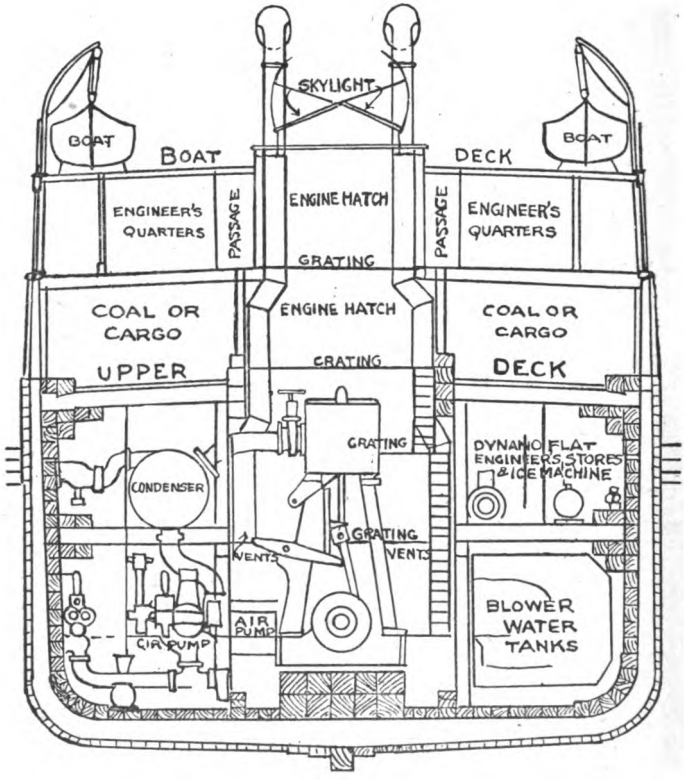

Figure 61.—Section Through Engine Room, Looking Forward.

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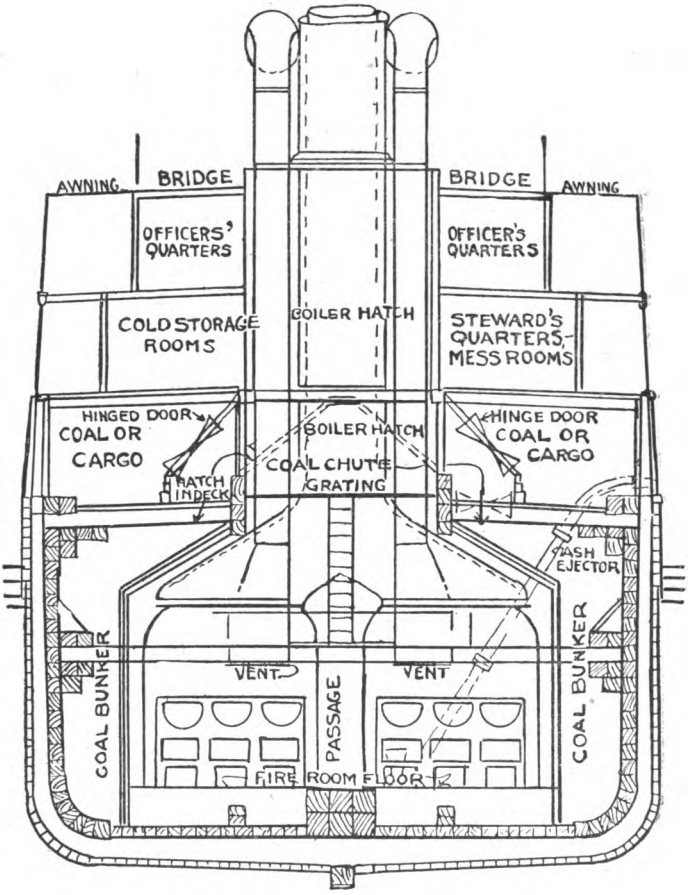

Figure 62.—Section Through Boiler Room, Looking Aft.

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Garboard Strake.—First strake sided 10″, moulded 14″, second strake sided 8″, moulded 14″, third strake sided 6″, moulded 14″, yellow pine.

Outside Planking.—Bottom planking sided 5″, moulded 14″, bilge planking sided 6″, moulded 10″, side planking sided 5″, moulded 10″, 5″x9″, 5″x8″ and topside planking sided 6″, moulded 9″, yellow pine.

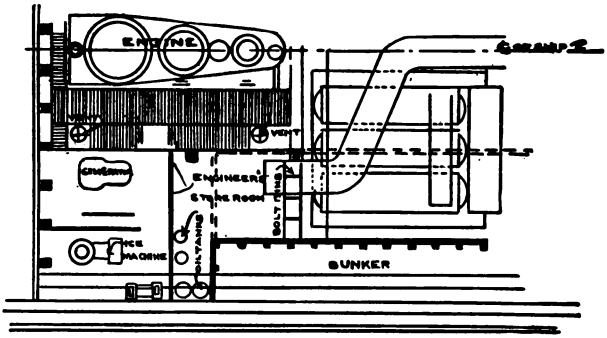

Figure 63.—Plan View at Dynamo Flat and Engineer's Store Room.

Main Clamp Timbers.—Sided 14″, moulded 14″, yellow pine.

Upper Deck Beam Shelf Timbers.—Two strakes sided 10″, moulded 12″, one lock strake sided 12″, moulded 12″, one bosom strake sided 14″, moulded 14″, yellow pine.

Hold Beam Shelf Timbers.—One strake sided 10″ and moulded 12″; one strake sided 12″ and moulded 12″, one strake sided 12″ and moulded 14″ and one bosom strake sided 14″ and moulded 14″, yellow pine.

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Upper Deck Waterways.—Two strakes each sided 14″ and moulded 14″, yellow pine.

Upper Deck Beams.—Sided 12″ and moulded 14″, yellow pine.

Hold Beams.—Sided 14″ and moulded 16″, yellow pine.

Pointers and Hooks.—Sided 3″, moulded 12″ in three and four thicknesses and two widths of 12″, yellow pine.

Logging Knees.—For upper deck 9″, otherwise 6″, hackmatack, oak or cedar.

Upper Deck Decking.—4″x4″, yellow pine.

Bridge, Forecastle and Poop Decking.—3″x3″, yellow pine.

LOFTING THE SHIP

The lines are laid down on the mould loft floor full size, as previously described. See Figure 64.

If space will not permit the laying down of the full length, it can be laid down in two or three sections, one overlapping the other. The sections must be long, however, so that the lines may be properly faired up.

All sections are laid down and the lines proved before getting out the moulds. It is not an easy task to properly fair in these lines, for while looking at one portion of the ship, it is impossible to see the other end; yet much depends upon the accuracy of the mould loftsman in getting out his moulds, in order to conserve the labor of the car-

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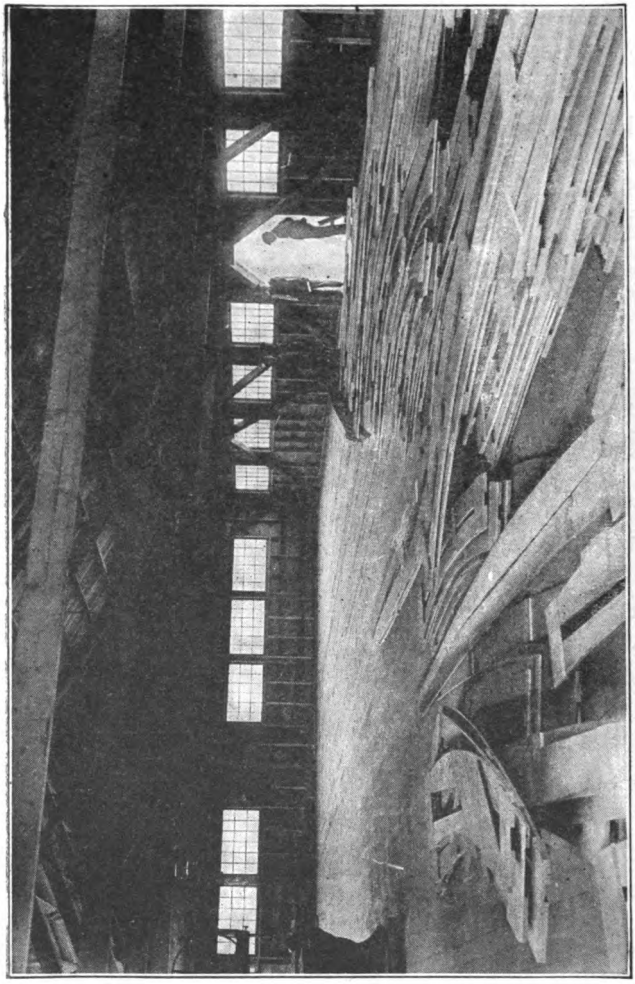

Figure 64.—Mould Loft.

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penter in dubbing off and fairing up the scantlings while in frame.

MOULDS

Experience has shown that the easiest and least costly method of getting shapes of the numerous

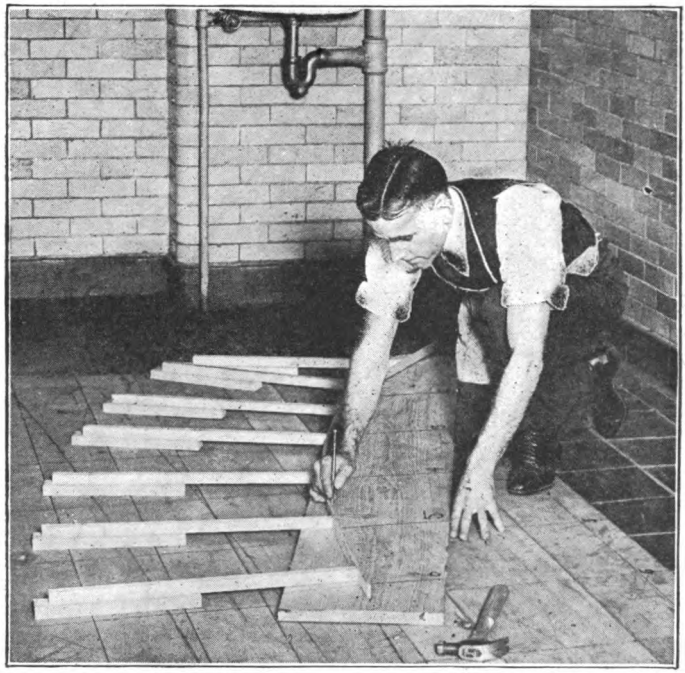

Figure 65.—Picking Up Lines.

pieces of material that compose a hull, is to make wood templates or patterns, called *moulds,* of each piece and use them as guides for marking and

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shaping the pieces of material that will be used for constructing the hull.

Making moulds is comparatively easy, provided the lines have been properly faired and the mould loftsman has done his work properly. The moulds will enable the yard superintendent accurately to

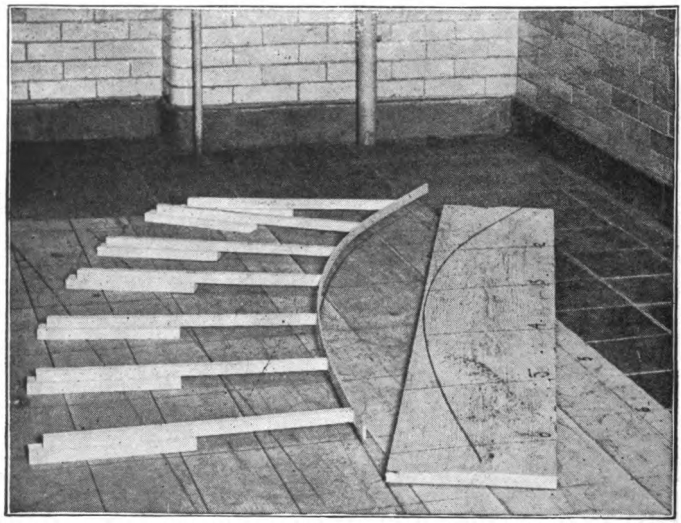

Figure 66.—Picking Up Lines.

shape the pieces at far less cost of labor than if they worked directly from measurements taken from the lines marked on the mould loft floor. The moulds are prepared by the mould loftsman, having plainly marked on them the various beveling stations, water lines, and other means of identification for ready reference when assembling. All

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have to be plainly numbered and show the number of pieces required. These are given to the mill superintendent and from them he lays out his parts. A method of picking up the lines is shown in Figures 9 and 10, using the heads of tacks. This method is used principally for picking up the lines for small members of the construction. Another method is shown in Figure 18, using a flexible steel template. The template is easily adjusted and saves a great deal of time. It will take in any radius up to 18″ and is made in lengths from 4 to 10 feet and up.

Still another method used in common in most shipyards is shown in Figures 65 and 66. With the other two methods there is a limit as to the sweep and length of line to be taken up, but with the method shown in these illustrations any line regardless of the sweep or length can be readily transferred from the floor to a mould.

A series of cleats is nailed to the floor, made of the same thickness of stock as the stock from which the moulds are to be made. They are placed far enough back from the line to come within the inside line of the mould and spaced according to the sweep of the line to be picked up. The quicker the sweep, the closer the cleats should be. A second group of cleats is nailed upon these cleats and project far enough beyond them to come within ⅛ inch or ¼ inch of the line to be picked up and to allow a thin batten to be nailed to the projecting ends. See Figure 65. The stock for the moulds is placed

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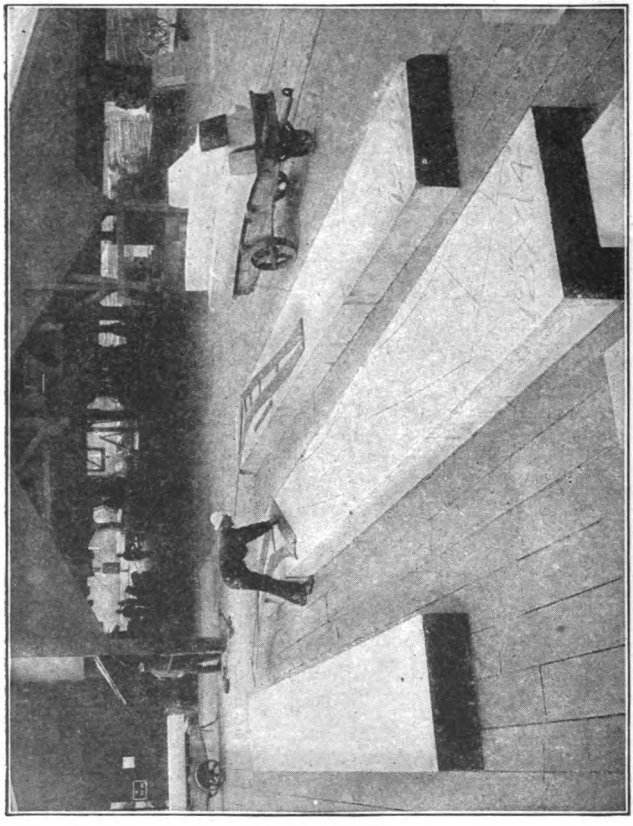

Figure 67.—Applying Mould—Laying Out Timbers.

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under these cleats and a pencil run along the batten and the line penned in. See Figure 66.

FRAMES

The frames are double sawed, spaced 36″ center to center, separated at the butts with 2-inch chocks, and each butt fastened with 1¼″ drift bolts.

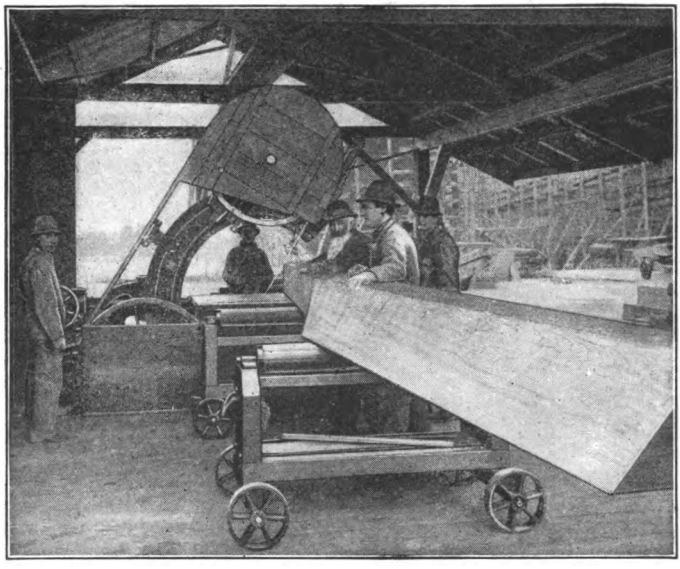

Figure 68.—Beveling Frames on the Band Saw.

The frames are laid out from the moulds, as shown in Figure 67, and cut to the required bevel on the band saw. See Figures 68 and 69. The gauge on the side of the machine registers the angle at which the saw is cutting.

The man guiding the stock through the saw an-

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nounces the various degrees or bevels as he nears the mark on the timber, while the operator at the wheel gradually tilts the saw one way or the other,

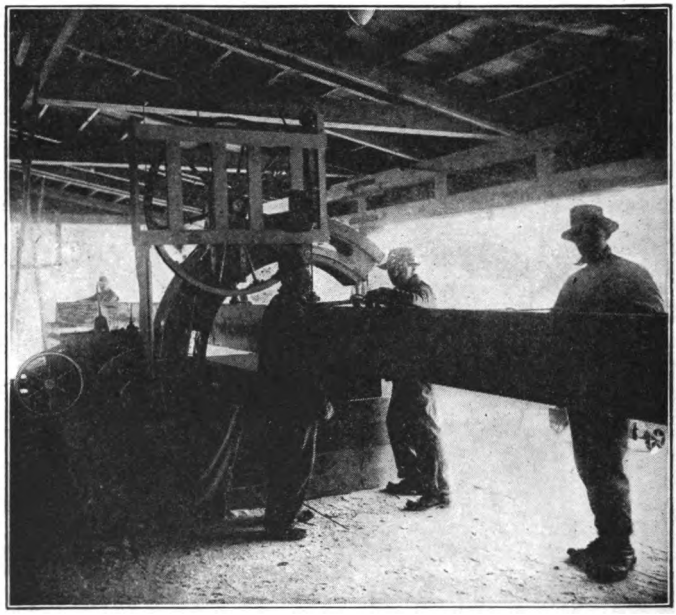

Figure 69.—Cutting a Straight Timber on the Band Saw.

as the case may be, fairing one bevel into the other as the degrees change.

Mill Floor Carriages.—In the well-equipped plant the mill floor is made up of sectional carriages, as shown in Figure 70. On the top of the carriages are a series of rolls.

The tops of the rolls are level with the working

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table of the machines, so that a heavy timber can be passed through a machine and moved about with but very little exertion on the part of workmen. The timbers are then put on trucks and distributed to the assembling platforms at the head of each "way." See Figure 71.

BUILDING BERTH

The building berth, or slip, or way, as it is sometimes called, is shown in Figure 72. It shows the

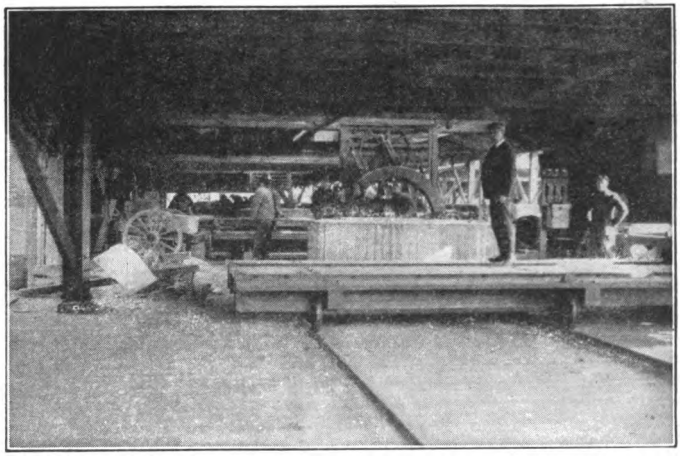

Figure 70.—Sectional Carriages in Mill for Handling Heavy Timbers.

arrangement of piling and heavy timbers upon which the ship is built and upon which the vessel slides in launching. The keel is laid upon a series of short timbers, called keel blocks, which are arranged on top of the building berth and are gener-

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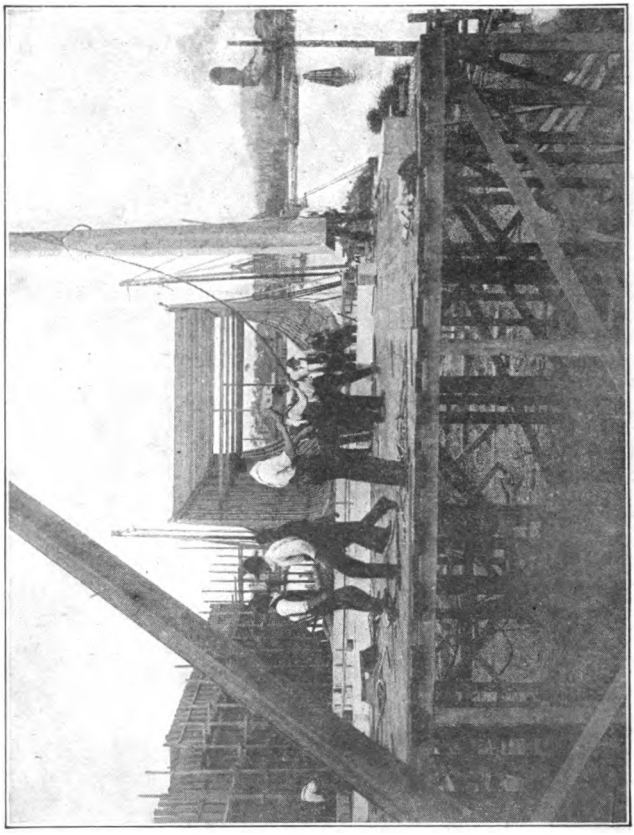

Figure 71.—Assembling Platform.

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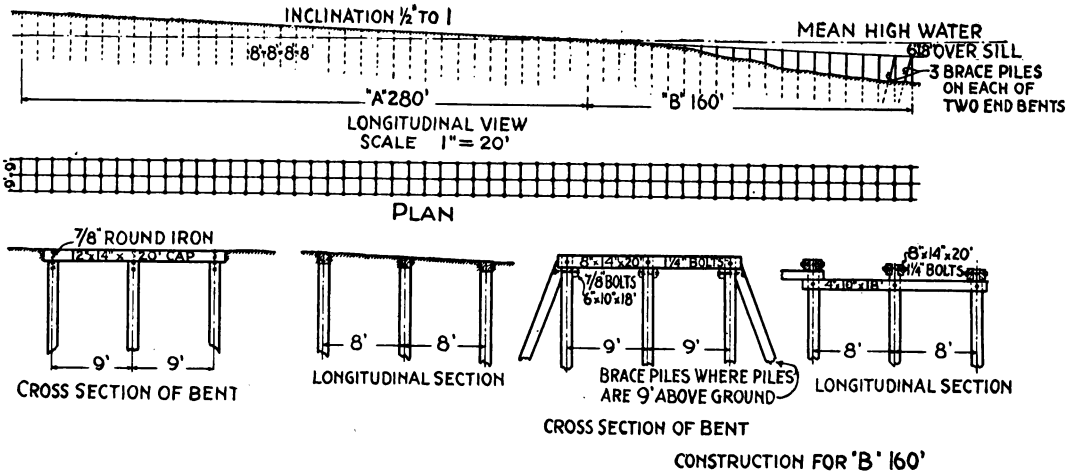

Figure 72.—U. S. Shipping Board Plan of Building Berth for Standard Wooden Ships. Length, 280 ft. Length Between Perps., 268 ft. Breadth Over Plank, 46 ft. Depth Moulded at Side, 26 ft. All Piles to Be Not less Than 12" at Butt and 5" at Point. About 200 Piles for Each Berth.

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ally placed directly over each piling. They should be so built as to be easily removed just before launching. The keel blocks raising the keel above the building berth afford access for the workman underneath during the construction. The building berth is built on an incline, as shown on the plan, which slopes downward at an inclination of ½" to 1'0".

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CHAPTER VI

MACHINES AND LABOR-SAVING DEVICES

Sawing and Handling Large Timbers.—Special machines and labor-saving devices have been designed to partially offset the shortage of labor. Figure 73 shows the method of sawing a heavy timber in a large modern mill. The first slab has been removed and the second cut is being made. The timber rests on a carriage which slides back and forth, and is controlled and held in position by a series of hooks operated by a lever on the carriage. The finished timbers are moved about in the yard on trucks, as shown in Figure 74.

Bevel and Edging Machines.—One of the latest machines to be designed is a bevel and edging machine used for beveling ceiling and planking (including calking seams), and forecastle deck beams; also for faying knees, rounding edging of waterways, main rails, pin rails, etc.

In Figure 75 is shown a timber starting through the machine at an angle of 11 degrees to the right, and in Figure 76 the other end is shown coming out of cut at an angle of 11 degrees to the left, the angle continually changing as the work was done.

The finished timber as it left the machine is shown in Figure 77.

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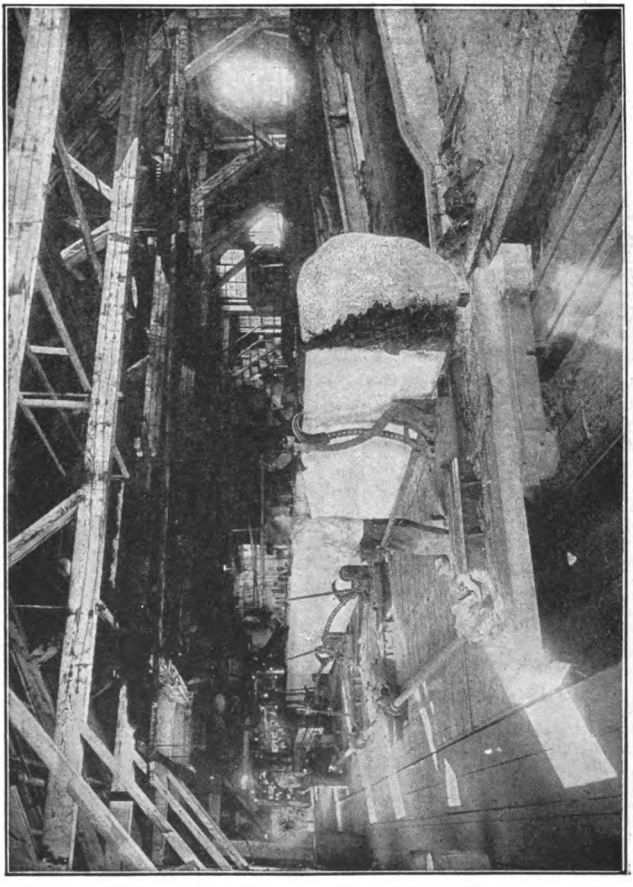

Figure 73.—Sawing a Heavy Timber in a Modern Mill.

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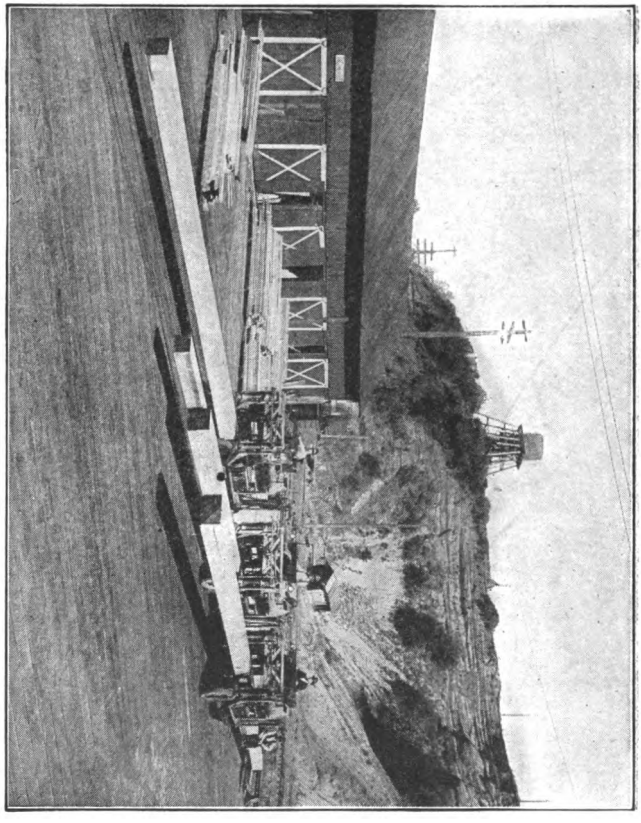

Figure 74.—Handling Heavy Timbers in the Yard.

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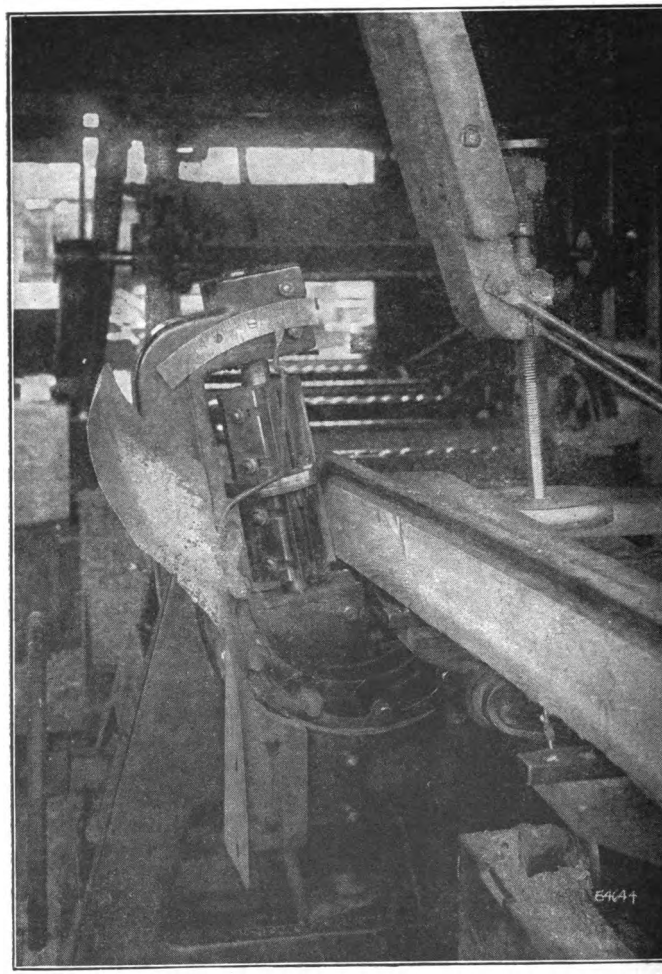

Figure 75.—Starting a Cut at an Angle of 11 Degrees to the Right.

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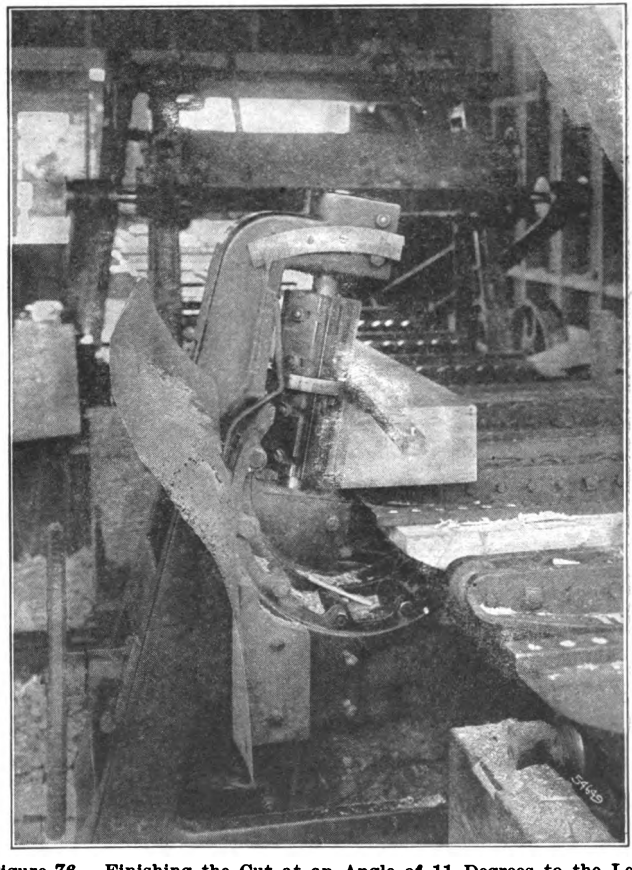

Figure 76.—Finishing the Cut at an Angle of 11 Degrees to the Left.

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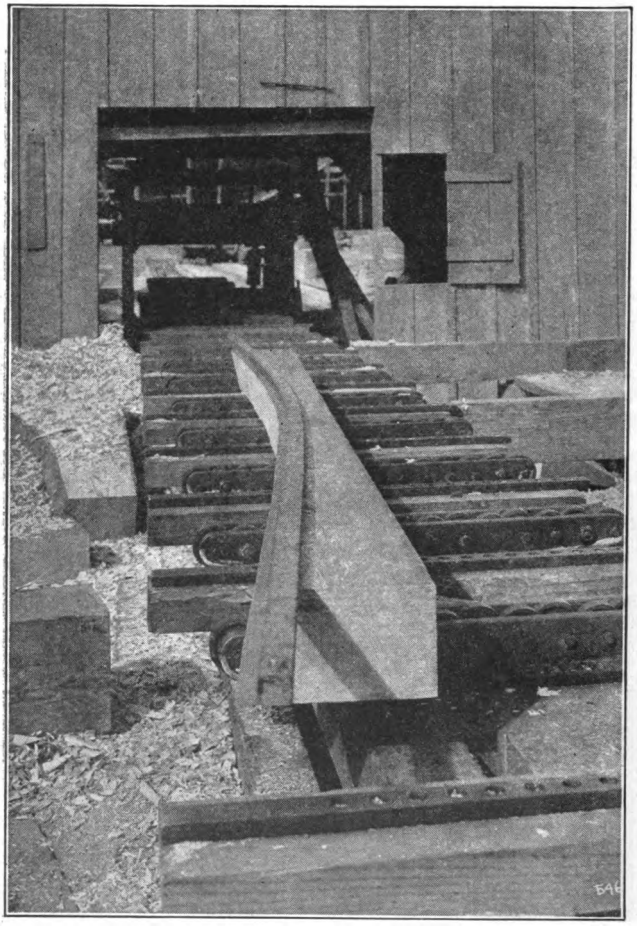

Figure 77.—The Finished Timber.

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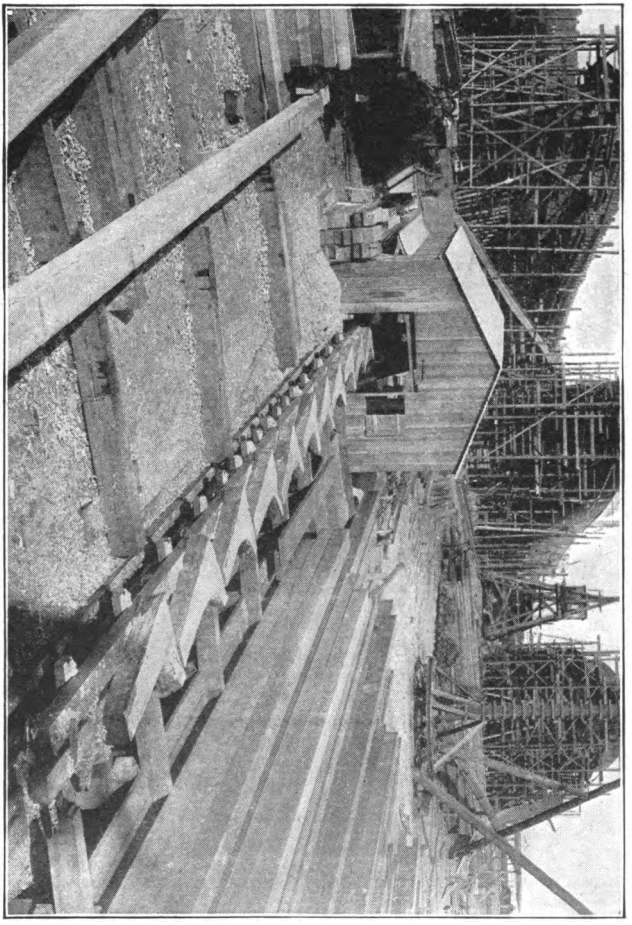

Figure 78.—Surfacing Knees on a Special Machine.

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In beveling ceiling planking, a complete strake can be laid out at a time; battens are nailed on each timber, and the timbers placed on roller skids alongside of the machine, from which they can

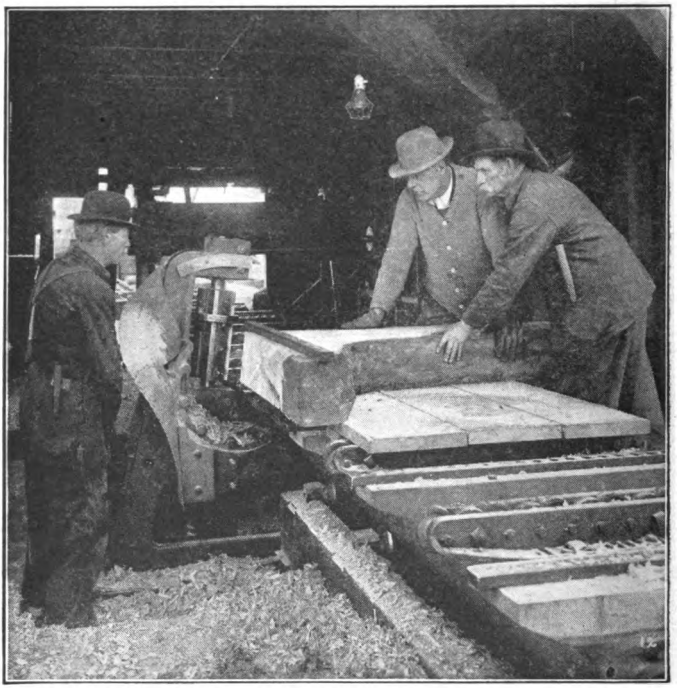

Figure 79.—Faying Knees on a Special Beveling Machine.

quickly and easily be placed on the carriage and run through. The collar of the machine rests against the batten, and this regulates the depth of the cut and the shape.

Surfacing Knees.—The method of surfacing

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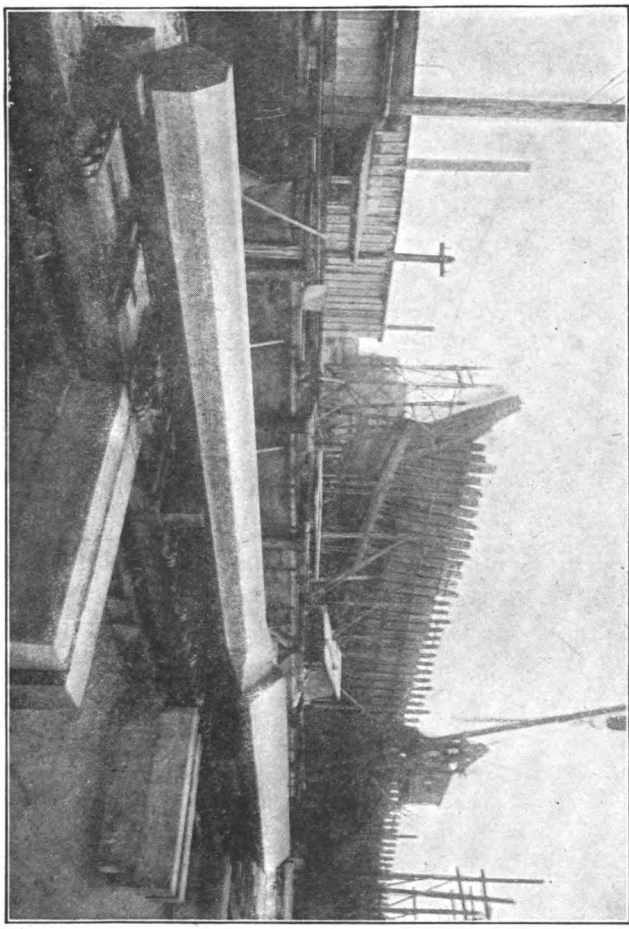

Figure 80.—Shaping the Rudder Stock on the Beveling Machine.

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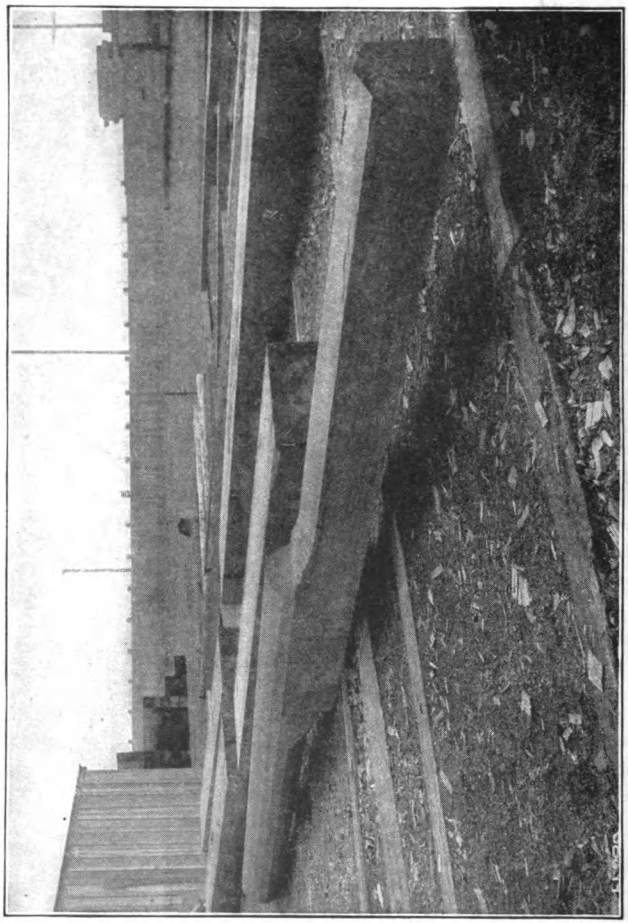

Figure 81.—Shape of a Rudder Stock After Sixteen Cuts Have Been Completed.

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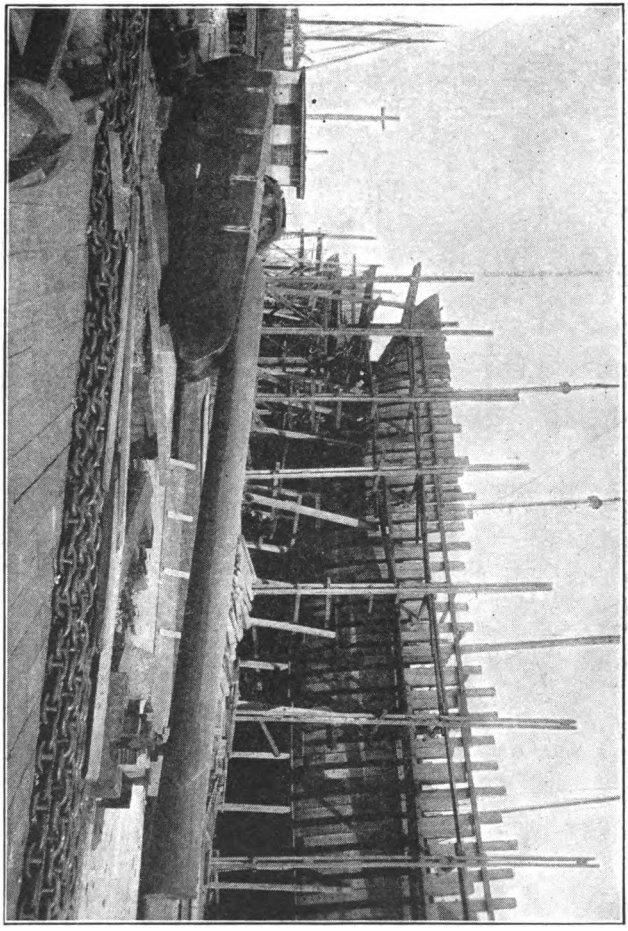

Figure 82.—The Rudder Stock Requires But Little Time with Hand Tools to Complete the Work After Leaving the Machine.

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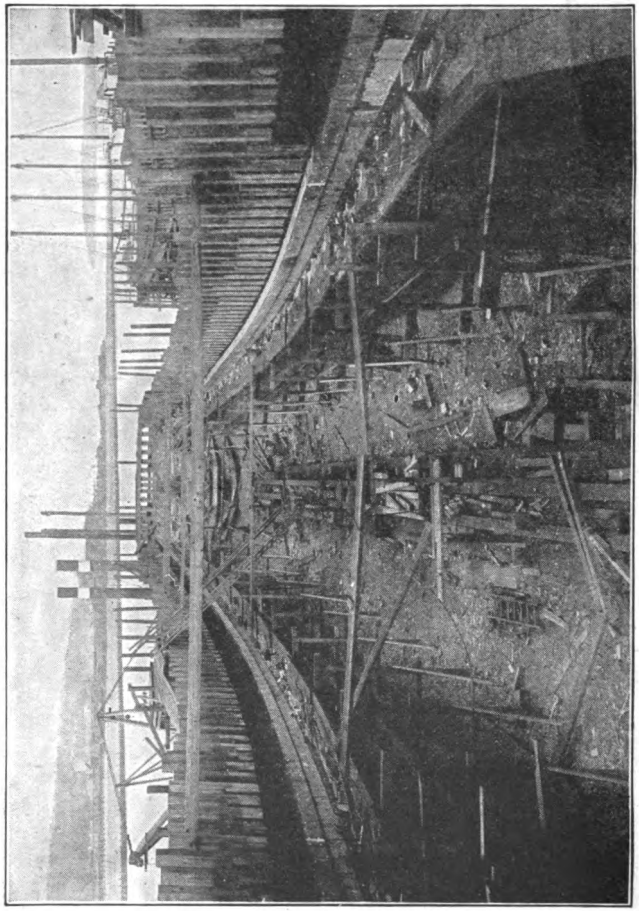

Figure 88.—No Hand Tools Were Used in Beveling the Ceiling in This Ship.

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knees is shown in Figure 78. Eleven knees are shown after having been surfaced two sides. These eleven knees were loaded on the carriage, surfaced one side, turned over and surfaced on the other side, the complete operation requiring only fifteen minutes.

"Faying" the knees is a simple operation, as shown in Figure 79. A small platform is placed on the carriage, and a batten is nailed on the knees in the same manner that is used in working ceiling and planking. To illustrate the work accomplished the carriage was reversed and the machine stopped.

Working Rudder Stock.—The working of the rudder stock shows another possibility of this machine. Formerly all the work was performed by hand, while the surfacing of the various parts is now done on the machine.

In Figure 80 the rudder stock (iron bark) is placed on blocks sawed to hold it at 45 degrees, the carriage of the machine is run forward, and the cutting done on the top beveling head.

Figure 81 shows the same piece after sixteen cuts have been completed, the lower part beveled two ways, and the sides surfaced. It leaves the machine as shown in Figure 82, practically finished, requiring comparatively little time with hand tools to complete the work as shown in the illustration.

Every piece of ceiling used in the ship shown in Figure 83 was beveled on this machine, no hand tools being used. Even the back of the ceiling at

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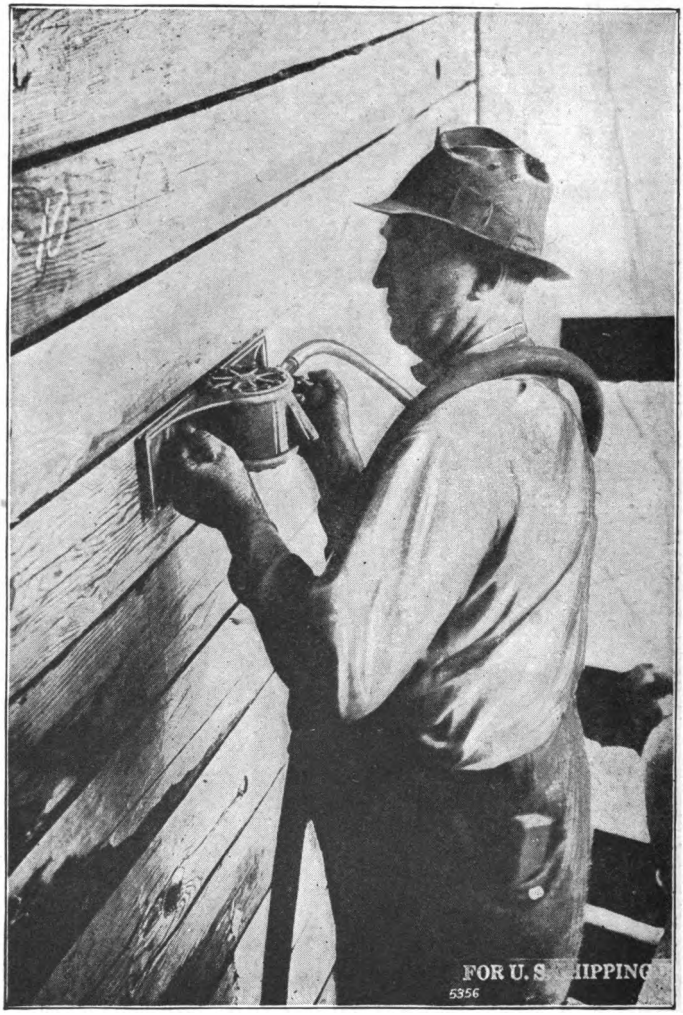

Figure 84.—Air-operated Hand Planer.

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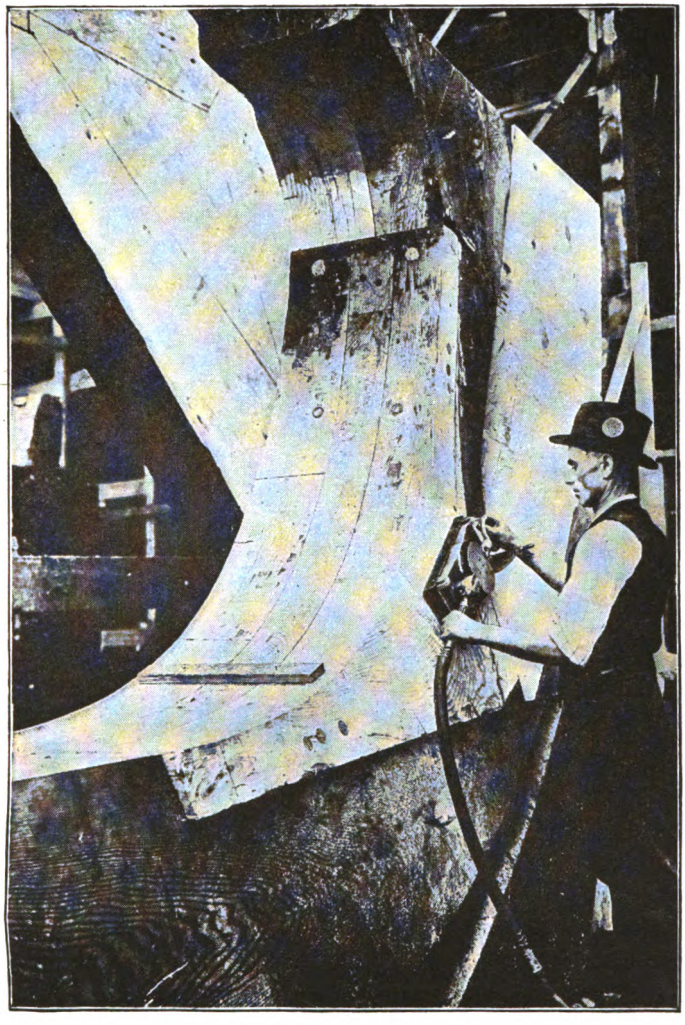

Figure 85.—Air-operated Hand Planer.

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the turn of the bilge was beveled, using the top beveling head of the machine, thus showing the amount of hand labor that may be saved.

Air Operated Hand Planers.—A novel tool called an air planer, has recently been developed for use in wooden shipyards. The device consists of a substantial base in which is fitted a revolving cutter head, the head obtaining its rotary motion from an air turbine. The planers are made in three models, of which one is employed for smoothing the sides of vessels, Figure 84, another for surfacing large timbers that are often too cumbersome to handle on an ordinary wood planer, Figure 85, and a third for cutting grooves in ships' frames to accommodate steel strapping. It is common practice for one operator to plane the underside of a vessel in eight hours, leaving a uniform smooth surface over treenails, knots, calking, marine glue and pitch pockets. This operation is shown in Figure 84. The air supply is controlled by a handle and the maximum depth of cut is 1/32 inch. This model weighs 10 pounds. The type used for surfacing large timber is shown in Figure 85. Here the operator has bevel-cut the edge of the timber to a mark and has set the machine for a deep cut with the object of effecting the operation formerly accomplished with an adze. This completed, the planer is set for a light cut to finish the timber. This machine is operated by a double turbine horizontally mounted on an adjustable carriage. It weighs 21 pounds, and is somewhat heavy for one man to handle on outboard work.

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CHAPTER VII

RAISING THE FRAMES

Setting Up the Keel.—The keel, Figure 86, forming, as it does, the backbone of the ship, is made of yellow pine, 16 by 14 inches, in lengths of about 40 feet, scarphed together with 7-foot scarphs. Each

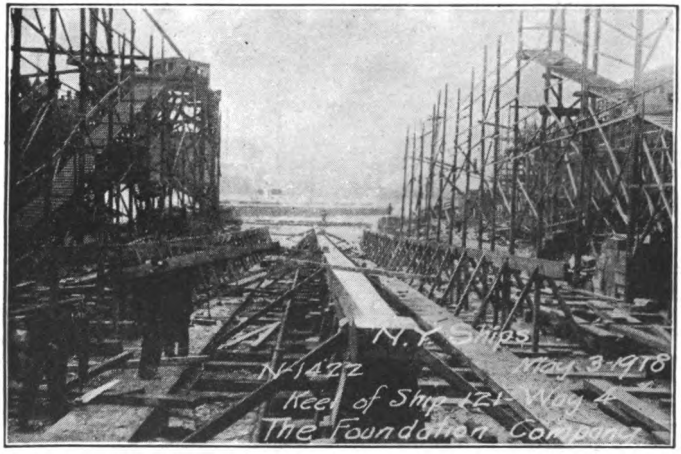

Figure 86.—Record Keel Laid in Ten Minutes in a Prominent Yard on the Atlantic Coast.

scarph is fastened with eight 1¼″ bolts set up over clinch rings, wedged and shored into position. The keel is laid upon keel blocks so arranged that they can be readily removed before launching. Wooden ships have a tendency to drop at each end after launching and very often the keel is laid with a

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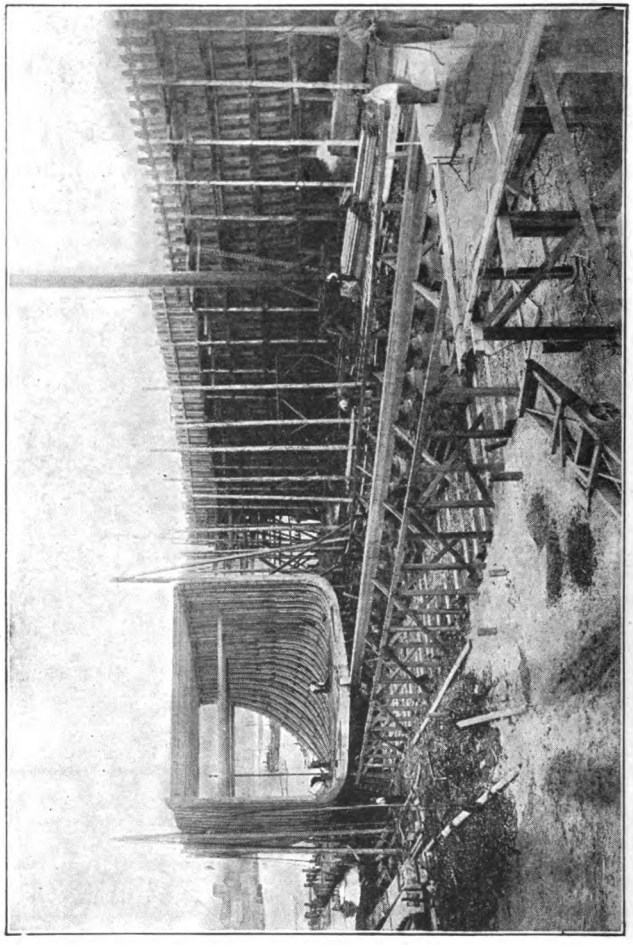

Figure 87.—Assembling Platform, Showing Ways and Square Framing.

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spring or sag in the middle so that after launching, the keel will have a tendency to straighten out. The keel shown in Figure 86 probably holds the record, having been laid in 10 minutes in an Atlantic Coast shipyard. Station lines are marked on the top and down each side of the keel and numbered to correspond with the numbers given on the

Figure 88.—Assembling Platform, Showing Diagonals.

plans. This is very important as the various operations are performed by different groups of men, so that if each piece that goes to make up the construction of the vessel is plainly marked for identification from the mould loftsman who makes the moulds to the men that assemble the completed frame, each piece will readily reach the location for which it is intended.

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Assembling Platform.—At the head of each way is an assembling platform as shown in Figure 87. Timbers are fastened to the platform on the diagonal lines, and upon these timbers the frames are assembled as in Figure 88.

Fitting and Fastening Frames.—If the diagonal lines and other reference lines have previously been transferred from the moulds to the frame timbers before sawing, they will readily find their proper location. The timbers come already shaped from the band saw, so that very little hand work is required at this stage of construction.

After the joints are fitted, the frames are fastened together with $\frac{7}{8}$-inch drift bolts and $1\frac{1}{4}$-inch treenails. The holes are bored with an automatic auger bit, followed up by a man putting in the treenails as fast as the holes are bored, and again followed up by two men driving in the treenails, so that by the time the last hole is bored the frames are practically ready to raise.

Raising the Frames.—As soon as the carpenters finish a frame, the riggers take charge in raising it into position. In Figure 89 is shown a frame about to be raised.

Two tracks are placed on either side of the ways, running from the assembling platform the entire length of the ways, and on these tracks the frames are run to their positions. Chocks are placed against the previous frame raised, to give the

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proper spacing of the frames and serve as a stop as the frame slides down the ways.

Figure 90 is a nearer view of the frames in position ready to raise, and in Figure 91 a frame is being raised.

As soon as the frame leaves the platform, the next frame is begun, and in that way both riggers and carpenters are kept busy. While one assembles, the other group raises.

Figure 92 is a near view of the frames in position. Figure 93 shows the same ship a short time before, the ways having been lowered while the ship was on them, as shown in Figure 92.

In setting up frames it is customary to start at the after end of the ship, putting the after cant frames in position first and then framing up the square body, assembling the square frames on the platform at the head of each building berth and raising the frames into position as previously described. The frames are set square to the keel and square with each other.

The following method may be employed to determine whether or not the frames are vertically square with the keel: drop a plumb from the middle of the cross spall to the center of the keel, then measure off a distance on the keel from the station line or center line of the frame, a distance equal to half the thickness of the frame plus the thickness of the cross spall. This gives the corresponding distance from the center of the frame at the

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keel as the distance the plumb is dropped from the top. Measure abaft of this line a distance equal to the product of the declivity of the keel blocks per foot by the number of feet in height the cross spall is above the keel. For example, if the cross spall from which the plumb is dropped is located 20′ 0″ above the keel and the declivity of the keel blocks is ½ inch in one foot, then the plumb should fall 10 inches abaft of the line that it should, if the keel was level.

To determine whether or not the frames are horizontally square to the keel, the rule of 6, 8 and 10 can be applied. For example, measure up from the face of the frame on the keel 8 feet; then measure off from the center line of the keel 6 feet on the lower edge of the frame, if the diagonal distance between these two points is 10 feet, the frame is square.

It is unnecessary to square every frame in this way, for when one frame is set correctly, a number of others can be set by reference to it. It is, however, advisable to institute checks at intervals so that when the frames are shored and fastened the intended designed form of the ship will be carried out.

CANT FRAMES

The cant frames are the half frames at the fore and aft of a ship. It is usual to dispose the trans-

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verse framing of a ship entirely in planes perpendicular to the trace of the load water line, with the longitudinal plane of symmetry of ships.

This practice leads to a large and varying bevel being given to the frames at the ends of a ship with a very bluff bow or stern, and it becomes a prac-

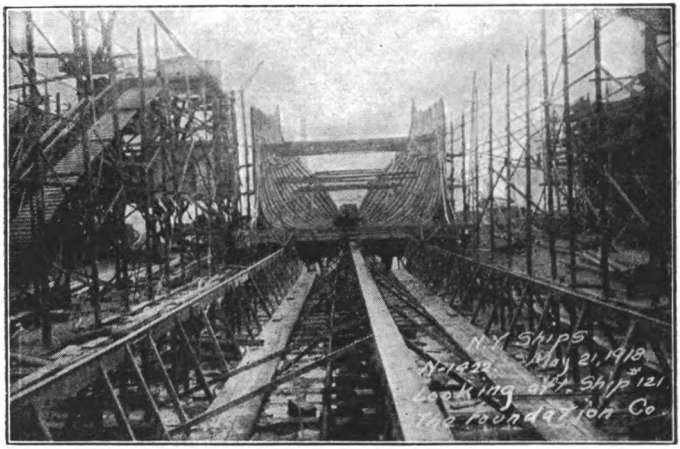

Figure 89.—The Frames Are Run on Two Tracks, One on Either Side of the Ways.

tical question whether it would not be better at such parts to dispose the frames in planes which are more nearly normal to the general surface of the ship, and which need not be perpendicular to either of the three planes of reference.

It is of great economical value and highly important that the timber frames be all square or nearly square sections, thus eliminating great bevels. Most of the bevels in wooden ship timbers

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do not exceed 10 degrees, very few exceeding 15 degrees.

Bolting the Frames.—The lower ends of the cant frames are let into the deadwood 1 inch and bolted with six bolts in each half—four 1¼″ and two 1⅛″. At least two of the 1¼″ bolts extend through

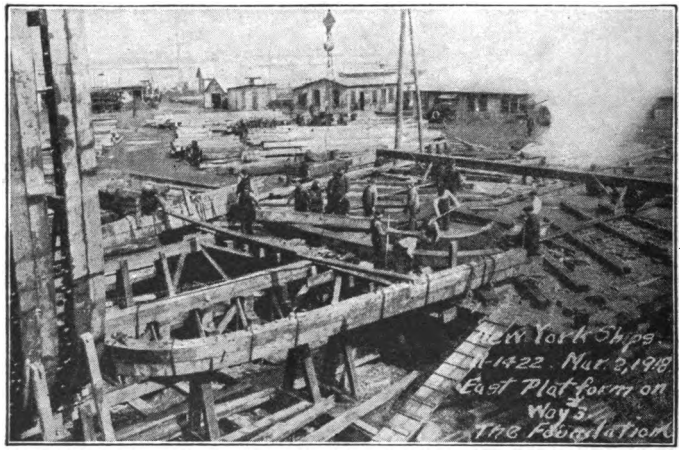

Figure 90.—Frames in Position Ready to Raise.

the half frame, through the deadwood, and set up over clinch rings.

The cant frames are built up in a similar manner to the main frames. Figures 94 and 95 show the heels of the cant frames fore and aft of the same ship. In Figure 95 the flooring is being laid and the illustration shows the long treenails in position ready to be driven in. A number are set up at one time and then the operation of driving them

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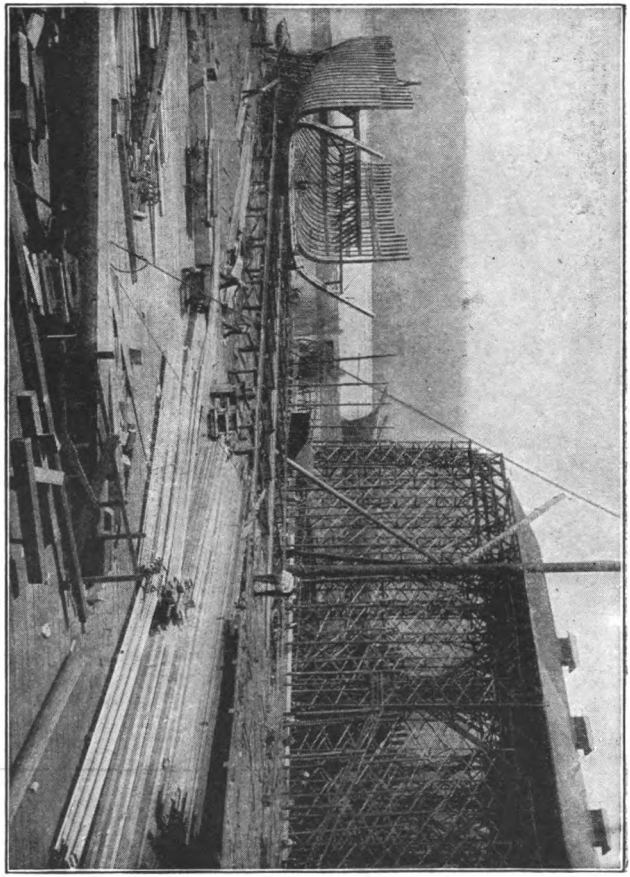

Figure 91.—Raising the Frame.

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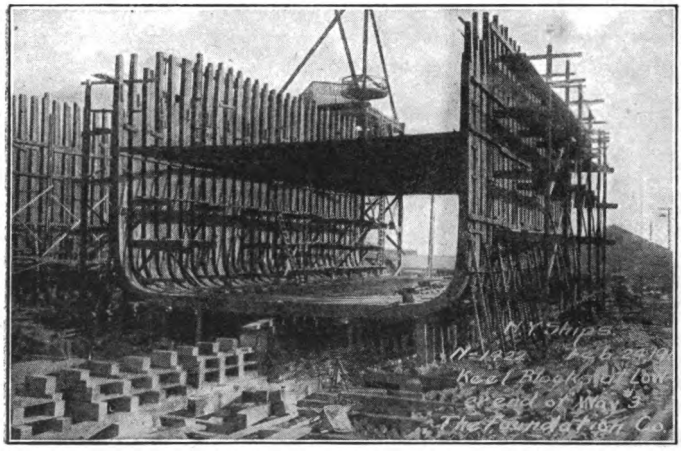

Figure 92.—Frames in Position.

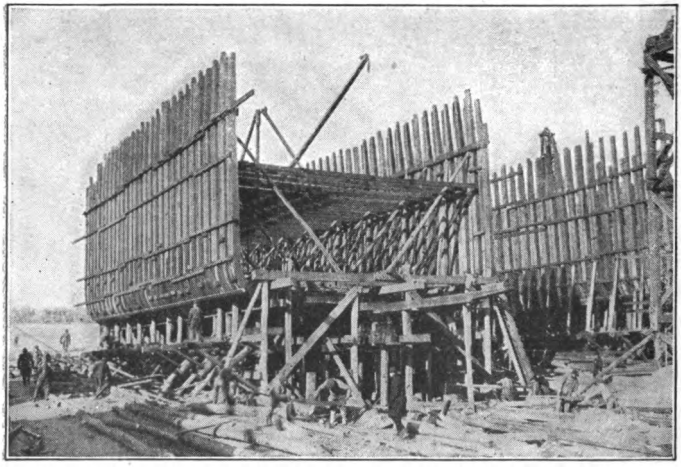

Figure 93.—These Ways Were Lowered While the Ship Was in Frame.

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is performed at one time. Figures 96 and 97 show the heads of the same frames.

Keelsons.—The keelson timbers are eight in number, as shown on the midship section, Figure 47. These are put in in lengths not less than 48

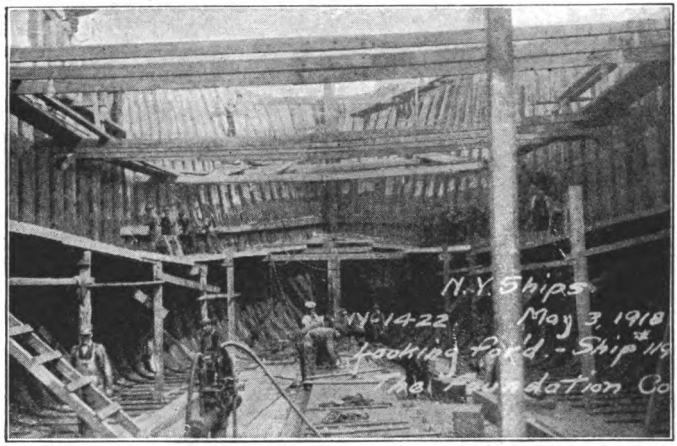

Figure 94.—Cant Frames Looking Forward, Showing Heels of Timbers.

feet long, connected with 7-foot scarfs, care being taken to get the best shift of scarfs possible.

Figures 98 and 99 show the keelsons being installed. At the lower left-hand corner of Figure 99 an opening is seen in the frame work. This opening is made after the frames are in position, and leads to a chute through which the heavy timbers of the keelson are hauled into position.

Fairing-up Work. — The framed body of the ship should be properly ribbanded and shored to

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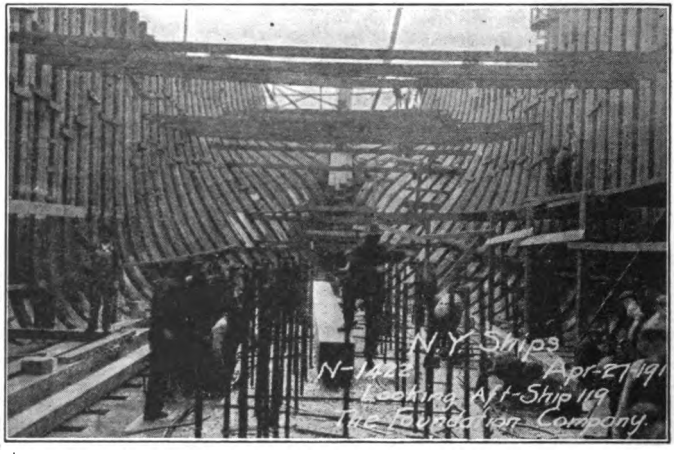

Figure 95.—Cant Frames Looking Aft, Showing Heels of Timbers.

Figure 96.—Looking Forward—Heads of Timbers.

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retain shape. The inside surface of the forms should be dubbed with an adze, so as not to leave over 10 per cent of the sawed surface on the frames. The outside of the frames should be dubbed for each strake of planking, and the outer surface of planking rounded to conform to the shape of the

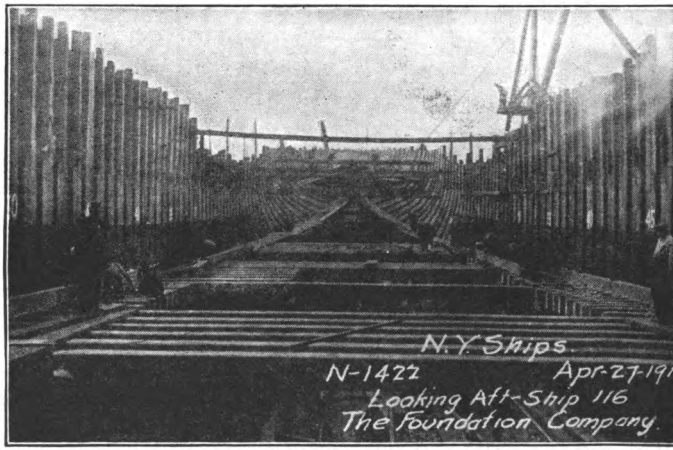

Figure 97.—Looking Aft—Heads of Timbers.

ship. The thick ceiling is rounded on the back, so as to fit the frames.

Iron Strapping.—The entire frame work is braced and reinforced by a system of iron strapping. A top belt of ¾″ by 8-inch iron extends from about 12 feet from the forward end to about 12 feet from the aft end of the ship, fastened to each frame by 1-inch by 10-inch countersunk bolts staggered. Diagonal straps of ½-inch by 4-inch iron

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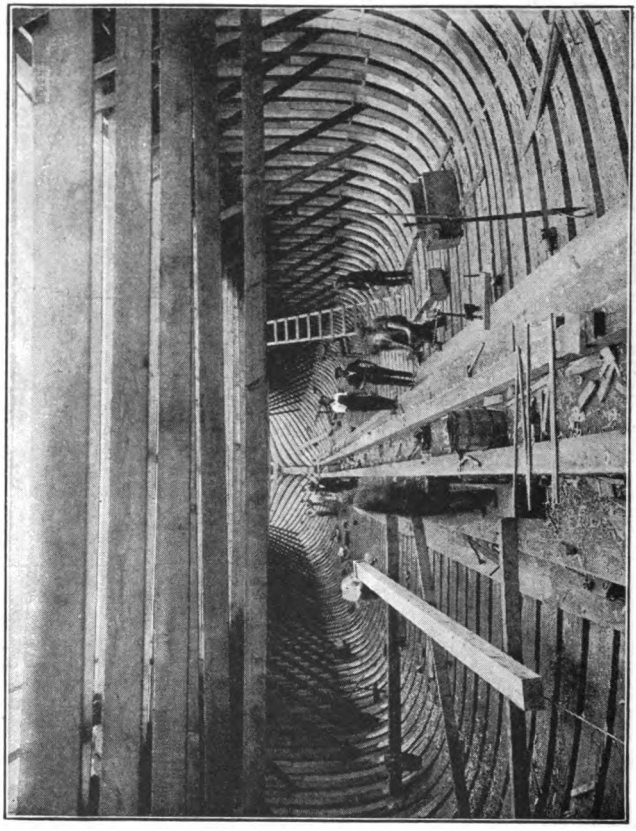

Figure 98.—Installing Keelson.

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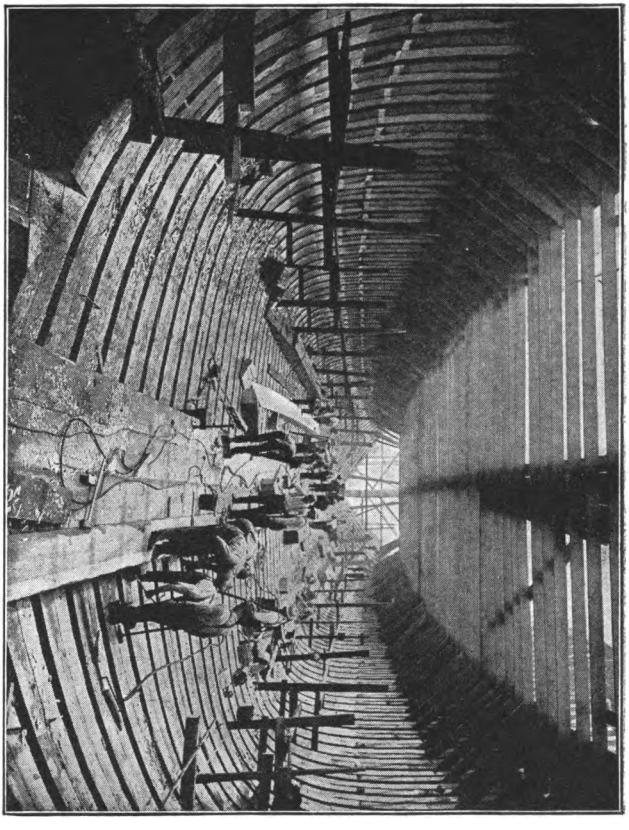

Figure 97.—Another View of Keelson and Timber Chute.

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are let into the outside of the frames and inclined at an angle of 45 degrees each way.

The diagonals are connected to the top belt by two 7/8-inch rivets and at each crossing by one 1-inch rivet, and also fastened to each frame timber by one 1-inch countersunk bolt. They should be carried well down and wrapped around the bilge far enough to overlap the ends of the floor timbers.

The iron straps should be painted with two coats of red lead and oil before planking.

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CHAPTER VIII

PLANKING AND FINISHING

Layout of the Ship.—Before going into the details of planking it will be well to refer to the

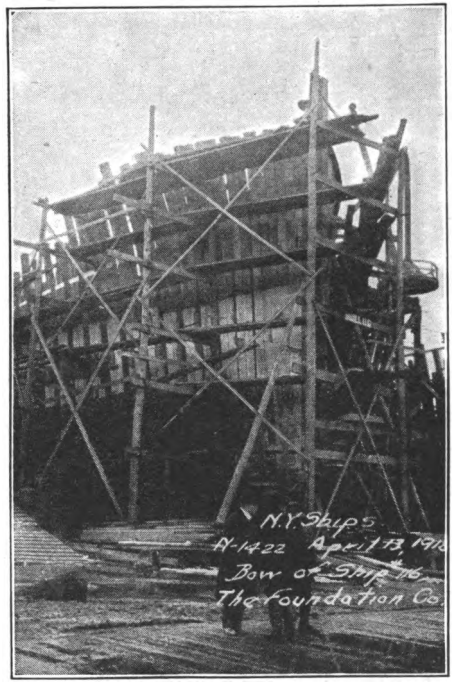

Figure 100.—Bow of Ship Ready for Planking.

illustrations to get the general layout of the ship before planking and in the finished state.

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Figure 100 shows the bow of a ship ready for planking. Figure 101 shows the same bow planked, with the staging still in position. Figure 102 is a closer view of the details of the bow construction.

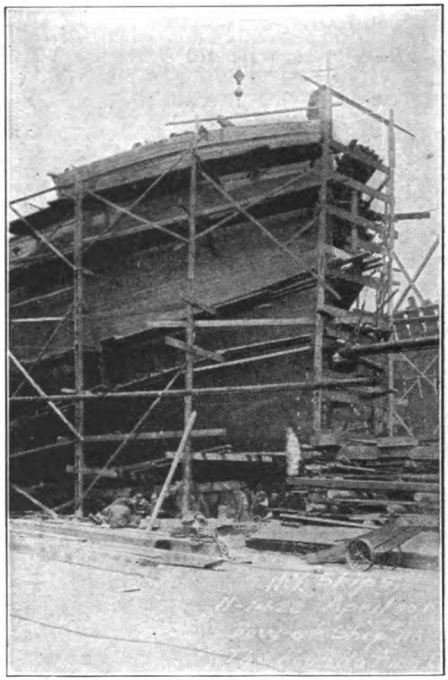

Figure 101.—Bow of Ship Planked, Showing Staging.

Preparations for Planking.—Figure 103 shows the starboard side of the ship ready to plank. Note the escaping steam, showing the location of the steam box used in bending the planking. Figure 104 shows the ship partially planked. In Figure

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105it is completely planked just before launching, and in Figure 106 the finished ship is seen after launching.

Material.—The planking and ceiling throughout is made of yellow pine lumber. The ceiling is put

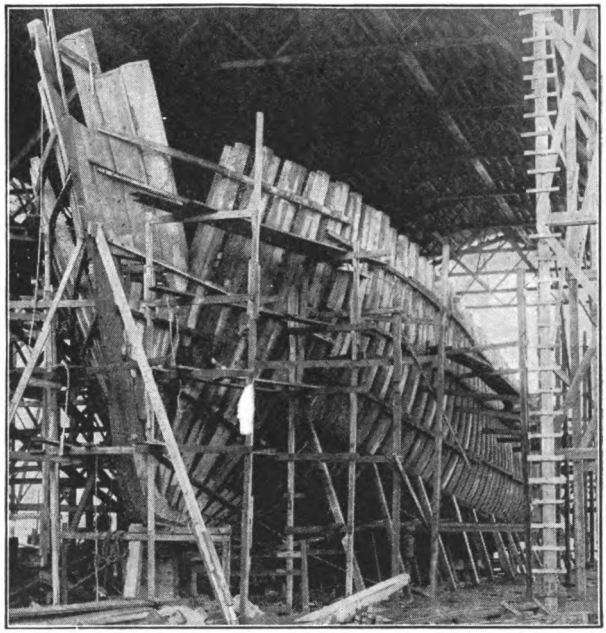

Figure 102.—Close-up View of Ship, Showing Detail of Bow Construction.

in in lengths 30 to 50 feet long, and the planking in lengths 24 to 40 feet, averaging 32 feet long. The bottom planking is 5 inches thick and 14 inches wide, bilge planking 6 inches by 10 inches, the planks narrowing as they reach up the side of the

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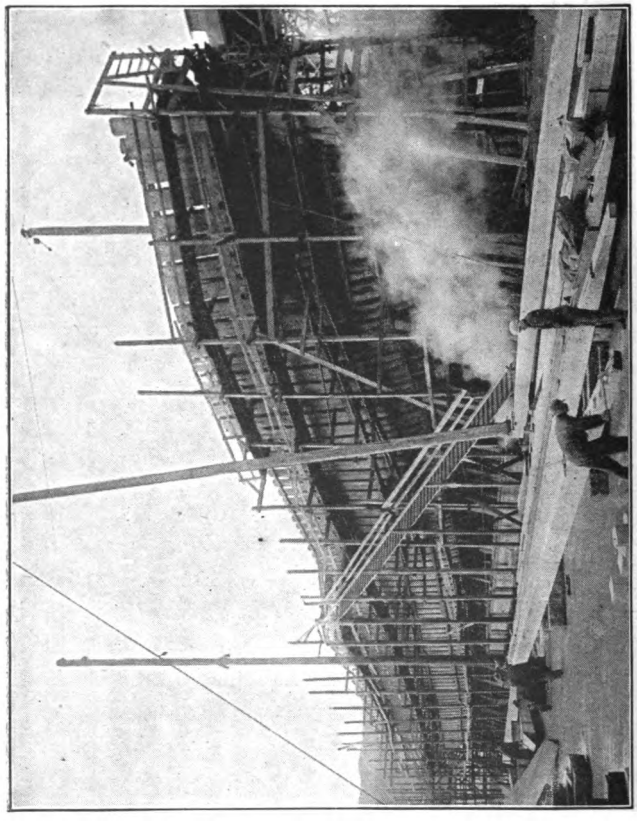

Figure 103.—Wooden Ship Framed Up Complete, Ready for Planking.

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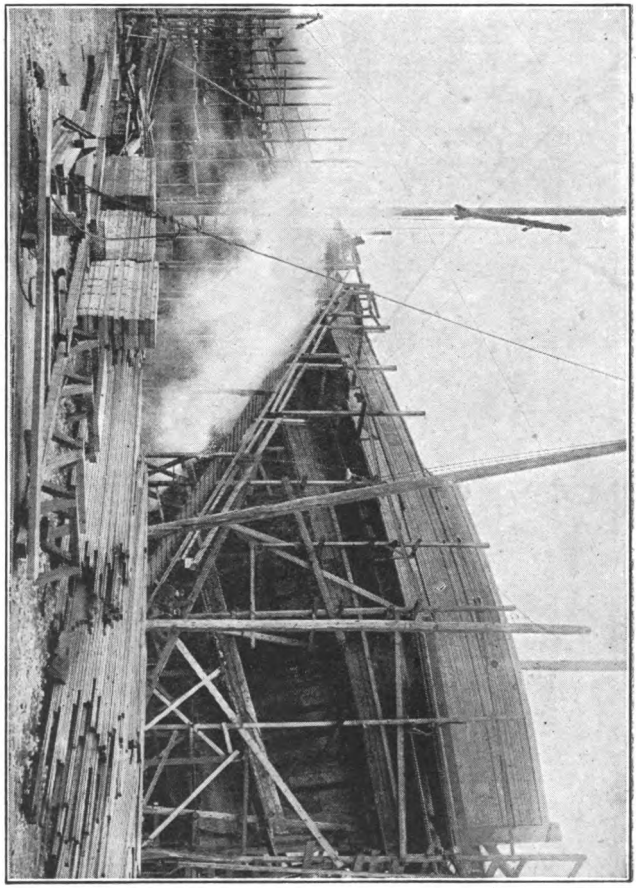

Figure 104.—Partially Planked.

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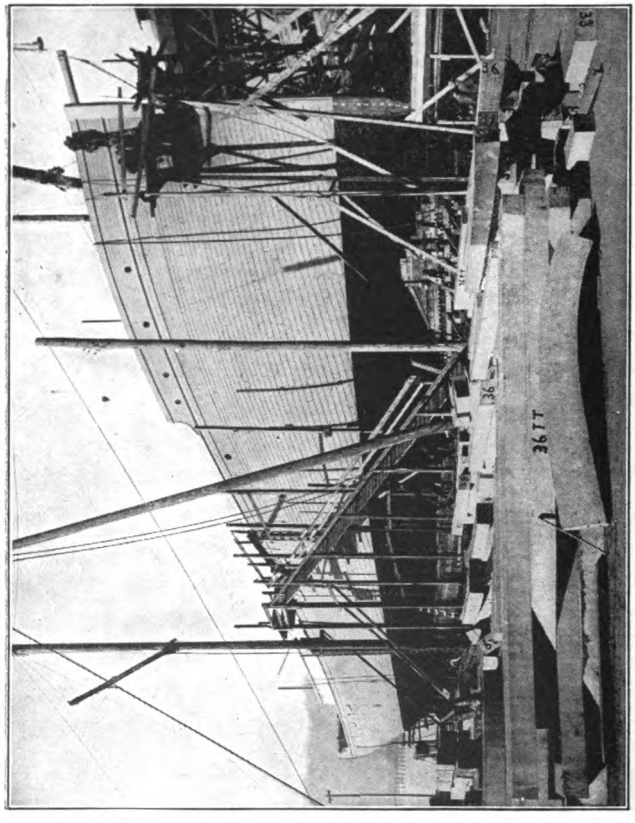

Figure 106.—Planked Ready for Launching.

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ship, beginning with 5-inch by 10-inch, then 5-inch by 9-inch, and 5-inch by 8-inch, the topside planking being 6-inch by 9-inch.

The lengths of the planking are jointed with square butts on the frames, with the seams outgauged for calking.

The circle of the stern between the knuckle line and poop deck is planked vertical, as shown in Figure 107.

Figure 108 shows the interior construction of a standard wooden steamship, looking aft. Figure 109 gives a close-up view of a framing platform.

The lines of the edges for several planks can be raised in on the frames to enable several groups of men to be employed advantageously in getting out and working the planking at the same time. The positions of these lines can be taken from the expansion drawings submitted by the naval architect. After a plank is worked to one of these lines the spiling for the top edge of the next plank can be taken in a manner as described on page 71. These spilings are generally taken at each frame center and at the same time and point the bevels for the edge of the next plank are taken and recorded. In this particular type of ship where the lines are not very irregular the bottom edge of the planking is left square with the face and the top edge of the next plank beveled to fit. By resting the stock of the bevel against the frames and adjusting the blade until it coincides with the edge of the planking, these bevels can be easily obtained. Or a

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square can also be applied with the blade resting against the frames and the tongue against the edge of the planking and registering on the spiling batten the amount of inches that the plank is out of square or the distance between the square and the edge of the planking. After the top edge is shaped, measure down from the inside edge of the planking the distances as recorded at their respective station, drive small nails in at these points and spring a batten through them. This will give the beveling edge while the moulding edge remains the same. These bevels may also be registered in degrees and worked on a special beveling machine as described in Chapter VI.

Steam Box.—The steam box for bending the ceiling planks is located inside the ship, while the boxes for bending the outside planking are located at the head of the ship or the most convenient place possible.

The steam boxes are made in lengths about 8 feet long and about 30 inches square inside the box. A number of these lengths are bolted together to get any length of steam box desired.

The timbers are cut to the required shape before steaming them.

Clamps and Wedges.—When ready to install, one end is fastened and held in position by a clamp, and as the plank is bent in position, a hook is fastened around the frames at intervals and a short timber is placed between the hook and the outside of the planking. Wedges can then be driven to

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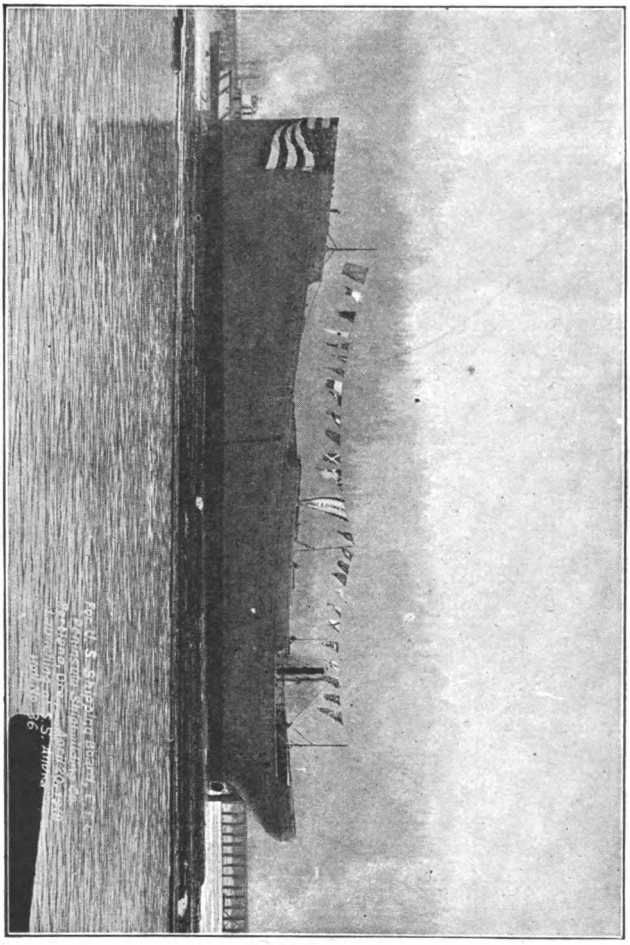

Figure 106.—The Finished Ship.

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bring the planking up tight against the frames. These hold it in position until fastened, when the wedges are removed.

The garboard strake is fastened to each frame

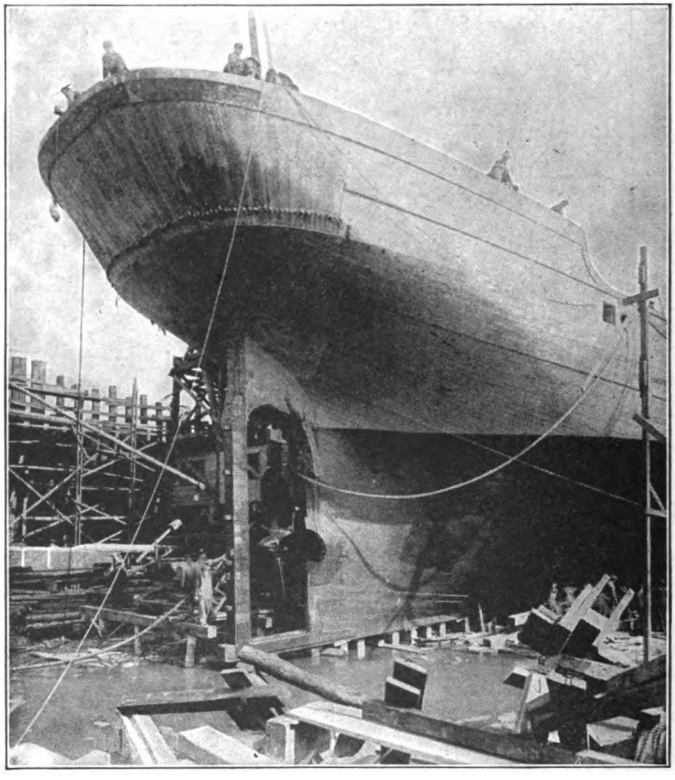

Figure 107.—Stern of Ship, Showing Vertical Planking.

with four 1-inch bolts 18 inches long, and edge bolted to the keel with 1″ by 36-inch bolts every second frame spacing.

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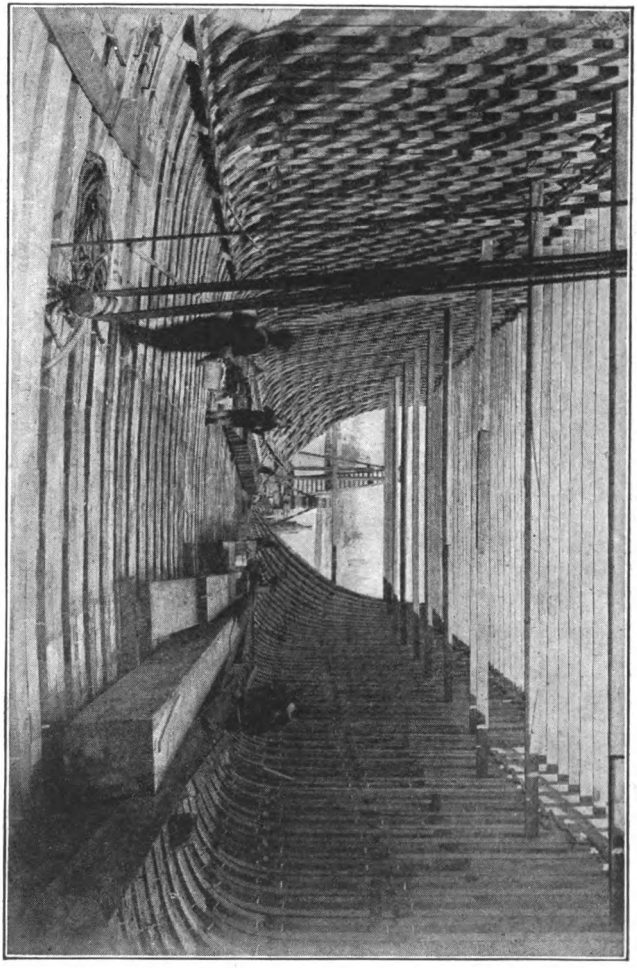

Figure 108.—Interior of Hull, Looking Aft.

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Bottom, Bilge, and Side Planking.—The bottom, bilge, and side planking is fastened with 5/8-inch bolts driven over clinch rings. These rings should

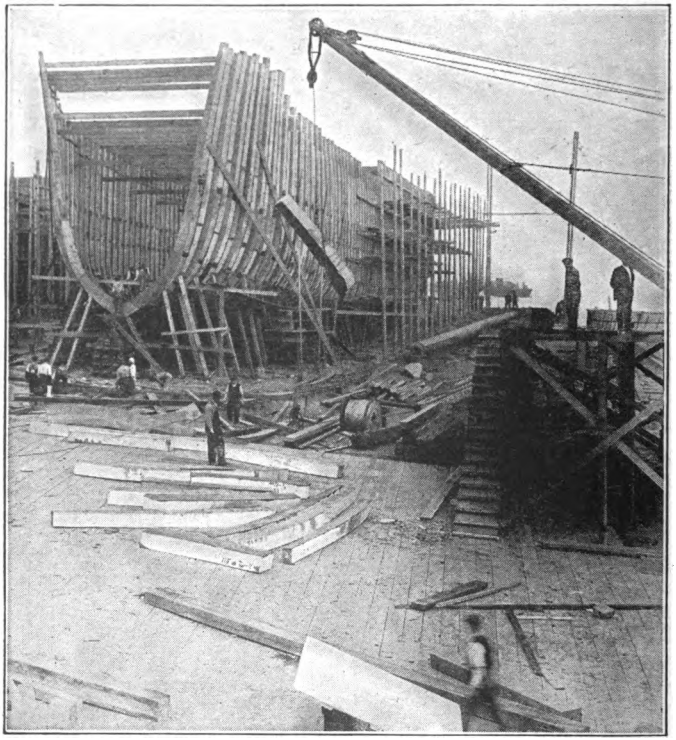

Figure 109.—View of Framing Platform.

be countersunk and the holes plugged, with the grain of the wood running in the same direction as the grain of the wood in the planking.

In addition to the bolts the wide planks have

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four treenails in each frame and the narrow planks two treenails, all driven in full length, wedged on outside of planking and inside of ceiling with oak wedges.

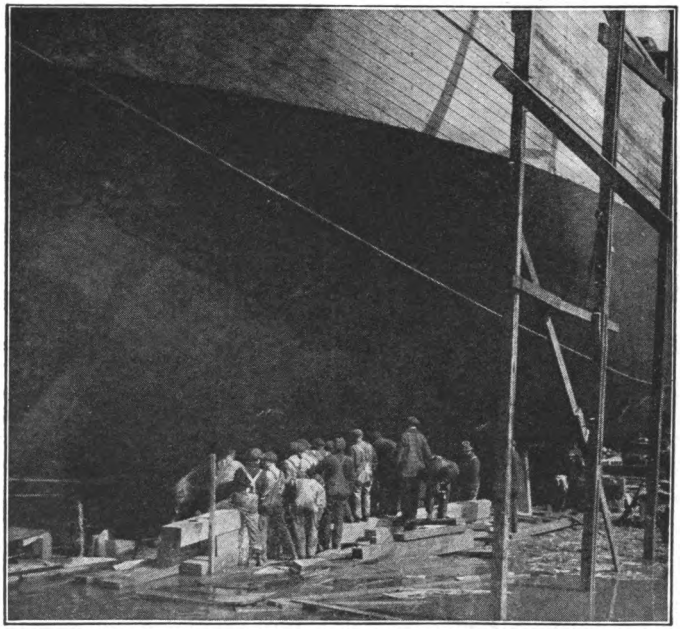

Figure 110.—Ready to Launch.

The wedges are placed across the grain of the wood through which they are driven. The holes for the treenails are bored with long, power, ship auger bits.

The head of each treenail is protected with an

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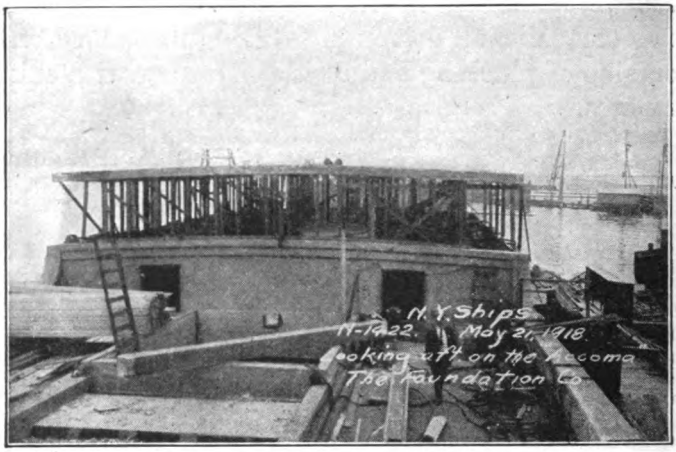

Figure 111.—Framing the Poop Deck.

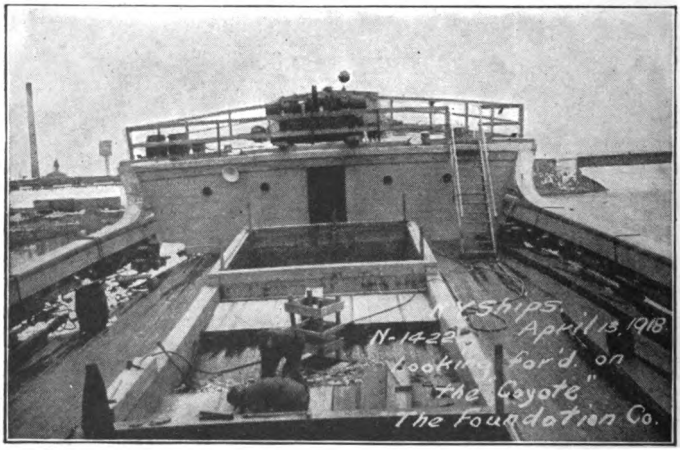

Figure 112.—Poop Deck Completed.

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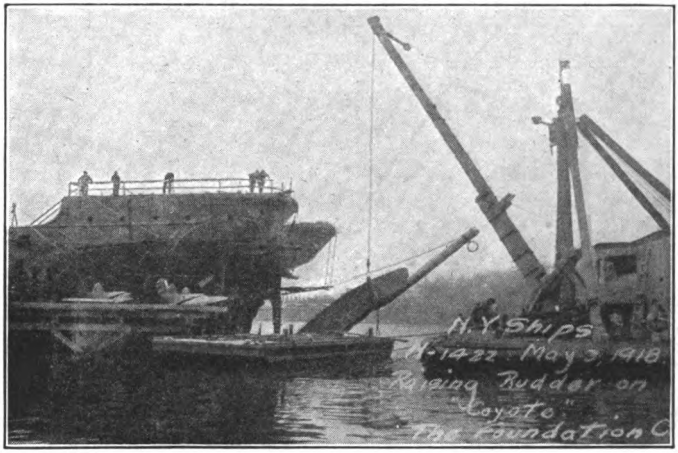

Figure 113.—Raising the Rudder.

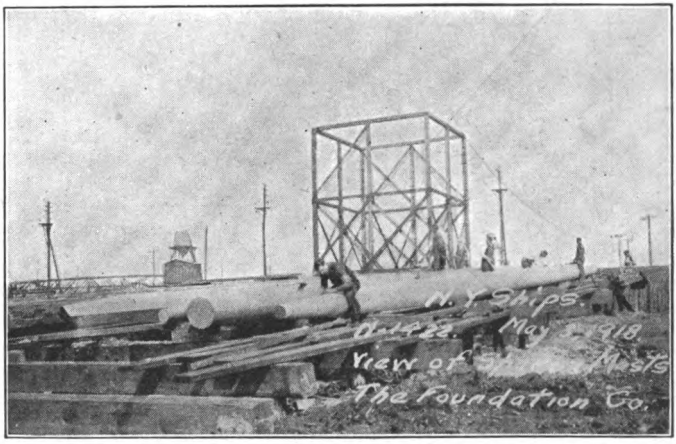

Figure 114.—Shaping the Masts.

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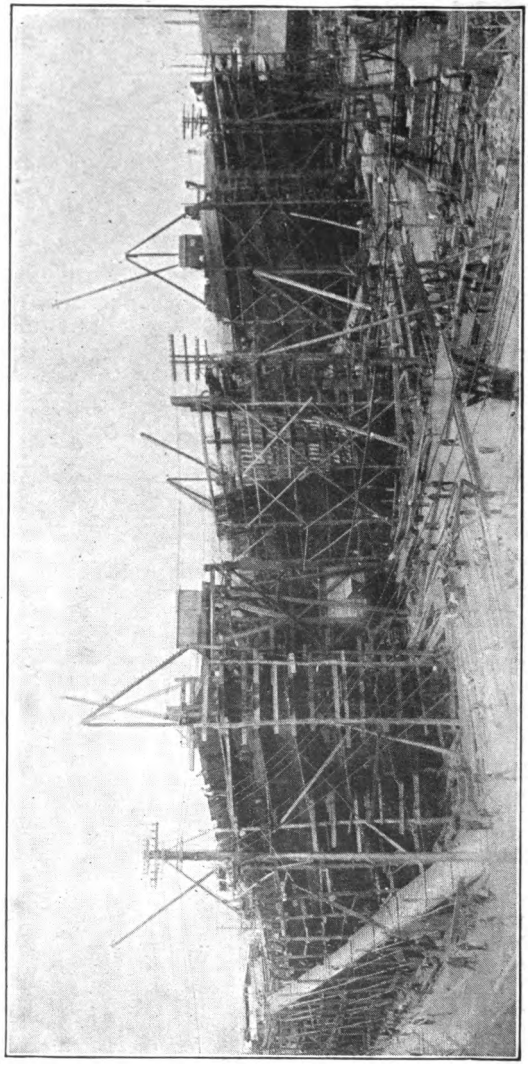

Figure 115.—Panoramic View of a Prominent Shipyard on the Atlantic Coast.

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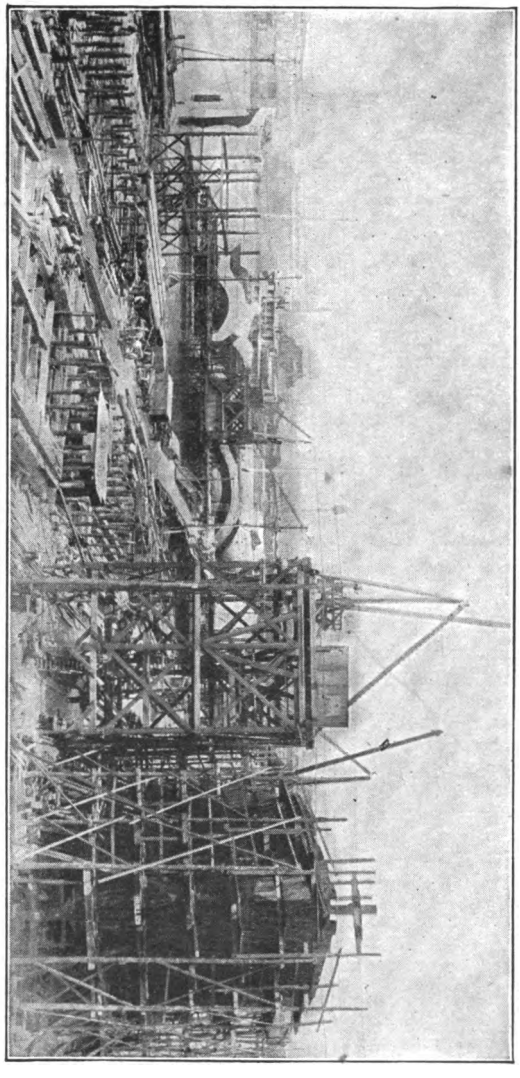

Figure 116.—Continuation to the Left of Shipyard Scene in Figure 115.

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iron cap to take the blow of the sledge while being driven in, to prevent it from splitting.

After the planking is fastened, the outer surface is rounded to conform to the shape of the vessel and joinered so as to properly take the paint.

Calking.—The seams in the hull are opened up with a dumb-iron where it is necessary to enlarge them to make room for the oakum. Beginning with the garboard, which should be calked with at least eight threads of oakum, the number of threads is reduced up to the five-inch planking, which should be calked with at least four threads of oakum, double horsed. The oakum is kept in the store room as it comes in bales, and is spun into threads for the calkers.

A deduction is made from the bevel angle for the calking seams. If the openings of the seams were of equal width throughout their depth between the planks, it would be impossible to make the calking sufficiently compact to resist the water. At the bottom edges of the seams the planks should be in contact throughout their length and from this contact beginning about the center of the plank they should gradually open upward, so that at the outer edge of the plank they should be open about 1/16″ in one inch of thickness of planking. That is, if a plank is 6 inches thick, they should begin to open upward from the center of the plank until at the outer edge the seams should be open about 6/16 inches.

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Cementing Seams and Painting.—The outside planking seams up to the 18-foot water line should be filled with cement, and the remainder of the outside seams painted with a white-lead paint and linseed oil.

The bottom of the vessel is painted with three coats of copper paint up to the light water line, and above the light water line a priming coat and two coats of pure lead and linseed oil.

As soon as the hull is completed the vessel can be launched, thus releasing the ways for the laying of another keel. The hull is then turned over to the shipfitters to complete. Figure 110 shows the hull of the vessel just before launching.

LAUNCHING WAYS

In order to launch a ship it is necessary to construct a special launching way for the purpose. The ship may be launched either sideways or stern first. The stern first method is more in general use, details of which illustrate the text.

The building berth or ways, Figure 72, must be so placed that the stern of the ship will be close to the water's edge and high enough above ground to afford access for the workmen during the construction of the ship. From the water's edge it rises on an incline of ½″ or more to the foot and down this incline the ship slides into the water.

The launching ways consist of two parts, the standing ways and the sliding ways. They are

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parallel to the center line of the ship and about one-third to one-half the half-breadth from it. The standing ways are fastened to the ground ways or building berth. The top of the standing ways is lubricated with about ¾″ of stearine and tallow, being held in place by steel plates to be removed before launching.

The sliding ways are then placed upon the standing ways and upon the sliding ways the cradle is constructed. The cradle is built up until it reaches the bottom of the ship. The cradle is kept from spreading by cables.

A series of wedges is placed at intervals above the sliding ways, and when the ship is ready to be launched workmen are stationed at each one of these wedges and, at a given signal, drive the wedges in; thus raising the cradle up and raising the ship with it until the keel blocks can be removed, thus freeing the underside of the ship until she rests entirely on the cradle. The ship is held in position and prevented from sliding prematurely by means of a safety dagger, or sometimes by a trigger arrangement which holds the ship back until at a given signal the dagger or trigger is released and the vessel slides down the ways into the water to be taken in tow by a tug and towed to the fitting-up wharf. When the ship reaches the water, the cradle frees itself and can be towed back to port.

Shipfitting.—Most of the difficult technical problems arising in ship work are found in the con-

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struction of the hull. When the shipfitters take charge, as is shown in Figure 111, framing the poop deck, the work takes on the nature of house construction, with the ordinary problems that may confront the average carpenter. Figure 112 shows the poop deck completed.

Raising the Rudder.—The methods employed in getting out the rudder stock have been shown in Figures 80, 81, and 82. Figure 113 shows the method of raising the rudder in position.

Shaping the Masts.—Each ship (standard carrier) is fitted up with two wooden pole masts, fitted with cargo booms. Figure 114 shows the shaping of the masts. These masts were completely shaped by hand, the rough cuts being made with an adze and finished with a hand plane.

Shipyards and Ways.—Figures 115 and 116 give a panoramic view of a prominent shipyard on the Atlantic Coast. Five ships are seen in course of construction and five ways are shown to the left of Figure 116, which is a continuation to the left of the view in Figure 115.

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CHAPTER IX

SHIFT OF SCARPHS AND FASTENING OF WOODEN VESSELS

General recommendations for the construction of the Ferris type wooden hull steamship that will conform to the requirements of the American Bureau of Shipping:

Keel.—To be laid with a sag and in a straight line latterly. A center line should be placed on top of same cut with a race knife. Keel scarphs to be fastened with two (2) clinch bolts in bay between floors only.

Scarphs to be stopwatered as follows: one fitted at corner of upper nib and one fitted 9″ below base line. Seam between stopwaters to be wedged both sides with white pine wedges. Wedging in this manner will make a permanently tight job, whereas ordinary calking will last only for a short period. Stopwater should also be placed at end of lower nib and seam between this stopwater and one 9″ below base line should be calked. This is done to safeguard against leaks due to heart shakes.

Stern Post.—Should be erected first after the keel has been laid.

Stern Post Stopwaters.—A 1½″ square white pine tongue to be put in center where 4 posts fay together, running full length of post.

At the bottom of stern post, where post is ad-

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jacent to keel, a 1½″ square stopwater running fore and aft, to be in post only.

One stopwater to be fitted between stern post and keel in way of rabbet and one stopwater to be fitted clear of rabbet. These stopwaters run through stern post, keel and fore and aft stopwater.

Stern Post Fastenings.—Stern posts should be fastened with two bolts every foot staggered of its length both ways. Fore and aft deadwood bolts will count as fastenings, provided they are driven through and clinched. In way of the boss, after the stern bearing bolts are fitted in place the post to be thoroughly fastened both ways before putting on stern bearing.

The deadwood knees to be worked next and properly fastened to stern post and stem. Follow with the deadwood up to the height of the floor timber, thoroughly fastening same with 1⅜″ clinch bolts, staggered 24″, which places them 12″ apart.

Cheek Plates.—These are improperly fitted in many cases. It is recommended that an exact form be made of ship at the boss, and the cheek plates furnaced and molded to this form. The holes below and above the shaft hole to be bored through the wood first, and then drilled in the cheek plate to correspond and the rivets put in. In all cases the cheek plate should fit accurately. Cheek plate should be laid in red lead putty.

Frames.—Should be carefully framed, and the butts to be closely fitted. Care should be taken to put the center line on floor timber exact. The

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frame should be carefully sprawled and stay-lathed. After the frame is raised the center line of same should be placed over the center line of the keel and the floor timber fastened to keel to hold it in position. The side of the frame should be carefully shored to keep it from sagging so as not to have them rack open at their butts in the bilges.

Each pair of timbers constituting a frame should be bolted or treenailed together.

Regulating.—Strong and substantial ribbands should always be used in regulating a ship, commencing at the head of the long floor and first futtock on the bottom. Frames to be properly spaced on this ribband square across the keel and the ship shored on this ribband and faired up. Next work a ribband about the center between the butt of the second and third futtock, carefully spacing the frame at right angles to the base line. The ship to be shored under this ribband and faired up the entire length. Then place a ribband in way of hold beams properly regulating the frames and shoring same. Next place a ribband at the main deck beams and fair up the ship at this point. No sagging of frames should be allowed.

The frames in way of keelson and ceiling then to be faired up by dubbing.

Keelson.—Keelsons should be installed next and all scarphs should shift one from the other at least 6 feet between them. Scarphs should be of key type. Build up deadwood at both ends and fasten same staggered 24″ apart with 1⅜″ iron. Place

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the shaft log according to plans, finish deadwood at both ends and completely fasten same while building it up 24″ apart staggered with 1⅜″ irons. The length of the fastening to be 2½ times the thickness of the piece fastened and to be driven tight. This method of fastening brings it up to specifications, namely: 24″ apart each edge or one bolt every 12″ per lineal foot of deadwood.

Where the main keelson consists of a single tier the fastening of the main keelson should be not less than two bolts through every floor timber and the keel, or a total of four per frame.

Where rider keelson is added to the main keelson, the fastening of the main keelson should consist of one bolt driven through every floor timber and the keel (a total of two bolts per frame) and the fastening of the rider keelson should consist of one bolt through the main keelson, every floor timber and the keel and one bolt through the main keelson and floor.

The fastening of the assistant keelson should consist of one bolt in each floor timber. The fastening of the assistant rider should consist of one bolt through assistant keelson and half way into each floor timber, and one bolt through the assistant keelson but not into the floor timber. Where the assistant rider is not added the assistant keelson should be square fastened.

The assistant keelson should be edge-bolted to the main keelson by one cross-bolt in every frame space, driven through assistant and main keelson

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and clinched. The above fastening is for double floors.

Horn Timbers.—To be fastened 18″ apart on each edge or 9″ staggered the entire length. The deadwood should be bolted 24″ apart, staggered. The filling timbers between the main stern post and the rudder post should be bolted together with 12 bolts or staggered 9″ apart. All to be of proper length, viz.: two and one-half (2½ times to one to each piece. The first two filling timbers adjacent to stern post to be through bolted and clinched on stern post.

Transom.—Transom should be worked next and put in place. The half frame on forward side of transom should be worked against same and to extend to the poop deck line.

Transom logs should be fastened together with bolts spaced not more than 24″ apart and should be fastened to the stern post with not less than four bolts clinched on oval washers.

Hairpin.—A hairpin mould for stern framing should always be gotten out in mould loft at the time of laying down stern framing. The hairpin should be placed about 2 feet below the poop deck line, extending at least 4 frames forward of transom and should be held in position aft of transom by shoring. Next, work on back side of transom, the timber to receive the heel of stern frames.

Stern timbers to be framed on the ground, to be put in place commencing at horn timbers fitting the keel against transom, toe fastening same to

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transom and one clinch bolt through timber fitted on back side of transom. The upper end to be stay-fastened through hairpin. At the knuckle, to have two bolts driven, one above and one below knuckle through horn timbers. Remaining stern timbers to be fastened in same manner entirely around stern.

Next work the radial timbers, dovetailing into transom and running to stern frames.

Next work knuckle rim around stern inside. The knuckle rim to be fastened to stern timbers with one bolt, each timber driven entirely through from outside and clinch on knuckle rim. Also fasten vertically with one bolt driven through each timber and clinched on top of knuckle rim. All bolts to be headed bolts.

Ceiling.—Bilge ceiling calls for an average length of 32 feet, the scarphs to be 7 feet long. It is quite impossible to install this ceiling to get a proper shift of scarphs. It will be necessary to split and lap the ceiling, care being taken to have the laps 9 feet and the shift of butts on the lower course not less than 6 feet and in the upper course not less than 9 feet. This can be done. Ceiling must be close fitted to frames and fitted tight on edges.

We suggest that the ceiling be worked in two places at the same time in the following manner in each side of the vessel:

Begin at the bottom alongside keelson and water course and lay ceiling edge bolting same as you go

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along, and at the same time begin on the side of the vessel at the first strake of ceiling under hold beams, and work upwards. Lay beam next, but leave out chocks between beams until all the ceiling has been put in and edge bolted.

The above in detail is as follows:

A. Commence at the keelson and work the 8″ ceiling out to the bilge strakes, edging bolting the same as it is being worked out.

B. Work the bilge strake next to the floor ceiling, edge bolting the same as you work upwards.

C. Side ceiling should be worked after bilge strakes have been worked and the shutter should be worked below the first strake of ceiling below deck beams. Hoods that require splitting may be done, all properly edge bolted up to this point.

D. At the same time work the first strake of ceiling below the tween deck beams. Next lay the tween deck beams, then follow upwards with the side ceiling and the upper deck clamp, all being edge bolted while working.

E. The filling chocks between the hold beams should be put in of 12″ material, when all the ceiling has been worked and edge bolted. Edge bolting of filling chocks to be staggered upwards and downwards, thus finishing the edge bolting complete.

Ceiling Fastenings.—The 8″ floor ceiling to be fastened edgewise and also 2 blunt bolts to go within ½″ of the outside of frame and at least 2 through treenails per strake per frame.

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Beginning at a point at the middle of the bilge strake, where the frame is less than 1½ times the thickness of the bilge strakes, one-half of the fastenings or two bolts to be driven from the outside through the frame and clinched on the bilge strake. All to be headed bolts. This method of fastening to be adhered to from this point to the gunwale.

The two blunt bolts in the ceiling should not be driven until all the treenail fastenings in the outside planking have been put in. The American Bureau surveyor will then examine the vessel and determine how many blunt bolts shall be driven in order that the vessel frame may not be over fastened in places.

Two ceiling bolts to be driven from the outside of frame and to be clinched on the ceiling. No blunt bolts are to be driven. Each strake of ceiling should have four treenails driven through from the outside planking. Great care should be taken for boring of the latter, so that they come through the ceiling regularly.

Treenails.—The treenails to be 1/16″ tapered up to 30″ long, 30″ and up ⅛″ tapered. The holes to be carefully bored with two different sized augers, so that the treenail fits tight throughout its entire length, and ferrule to be used. No parallel treenails should be driven.

As many treenails as possible to be driven through and carefully wedged on both ends. Short treenails not allowed. In case of striking iron

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should the depth of hole be less than twice the thickness of the outside plank, it should always be plugged with a dry white pine plug, otherwise the treenail to be sawed at the inner end and a wedge inserted and driven up tight.

It is further recommended that the treenails be driven as planking is being worked, otherwise the fastener will not be able to tell where the strapping iron and ceiling bolts come in the frame. Before plank is worked the fastener should always mark the location of his iron and transfer same on plank after it is worked before boring the holes for the treenails.

The holes should always be bored square through the face of the frame. Clustering of treenails inside will not be allowed.

After ceiling is installed and before outside planking is worked, the cross bulkheads are to be installed. These bulkheads must not be butted. Any scarphs worked must be 5′ 0″ in length, and then only every third strake may be scarphed. These scarphs must be staggered from one side to the other, so that bulkhead may have scarphs only in every third strake from top to bottom. Margin timbers to be immediately worked against side of ship alongside of bulkhead, these to be fastened with clinch bolts from outside of frame and also fastened forward and aft with screw bolts through margin timbers and bulkhead.

Shaft alley not to be butted. Scarphs 5′ 0″ in length to be worked and shifted at least 6′ 0″, one from the other. All to be properly edge-bolted.

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Strapping.—After sufficient ceiling has been worked in the ship to assure the builder that it will hold without moving, the vessel should then be blocked and shored on the bottom and the ribbands removed and all lines to be run for the outside planking and same faired up. Then proceed with cutting for the outside strapping. Care should be taken that the strapping be put on the vessel fair. Frames not to be cut any more than necessary. Strapping to be worked so as not to interfere with the outside planking. Strapping to cross each other in the center of frame space.

All strapping to be smith-welded into continuous length. Frames not to be cut too deeply and straps to fit close.

Outside Planking.—The garboards should be worked and the scarphs be shifted at least 6 feet away from the scarphs in the keel, also six feet away from one another. No scarph to come in line except if there be 2 strakes between when they may be opposite. That is, for instance: Work a first garboard forehood about 24 feet long on one side and a first garboard forehood on the other side, say about 36 feet long, the keel, being 48 feet long, gives you a proper shift. Now work a 36-foot forehood on top of the first hood 24 feet long on one side and on the other side work a forehood 24 feet long. Carry this arrangement throughout the length of the ship and you will have 6 feet between all scarphs and 2 strakes between opposite scarphs, counting the keel. Now place your butts of the

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third garboard on both sides in such manner as not to come near the above scarphs and have a proper shift away from them.

Planking Fastening.—Treenails or galvanized iron bolts may be used. Planks under 8″ wide should have two fastenings per frame; plank eight inches wide and under twelve inches wide should have four fastenings per frame; and planks twelve inches and under sixteen inches should have six fastenings per frame. Planks sixteen inches and over in width should have eight fastenings per frame.

The butts of each plank should have two bolts, one of which should be in the nearest timber to the frame on which the butt is lodged; and in all cases one of the bolts should be driven through and clinched on the ceiling. The hood ends should have a butt bolt in addition to the ordinary spike fastening.

Spike fastening in the body of the planking is not considered desirable, but when for any special reason it is adopted only one-third of the regular three fastenings in any frame timber, or one-fourth of the regular square fastening in any frame, may be spiked, two of which should be driven for each treenail or bolt omitted.

Spikes should be arranged so as not to fall in one continuous vertical row. The length of spikes should be one inch more than twice the thickness of the planks they fasten up to a thickness of four inches. Where the thickness is greater than four

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inches the spike should be driven five inches into the frame.

Size of Fastening.—All body fastening except that in the planking should have a diameter equal to—

$$\frac{S+M+P}{40}$$

where S = Siding size of timber to be fastened.
M = Molding size of timber to be fastened.
P = Average distance apart of the fastenings in the lengthwise direction of the timber to be fastened.

The same formula holds for the planking except that S= the average distance apart of the fastenings in one row in the lengthwise direction.

The size of the bolt fastening should be taken to the nearest eighth of an inch, going to the next higher eighth, where the formula does not give the diameter in even eighths.

Treenail and spike fastenings should correspond to the bolt fastening as follows:

Diameter Bolts, Inches	Diameter Treenails, Inches	Diameter Spikes, Inches
½	⅞	⅜
⅝	1	⅜
6/8	1⅛	½
⅞	1¼	½
15/16	1⅜	⅝
1	1½	⅝

Bilge Planking.—Begin planking with the first strakes on the bottom below the bilge strake at the

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same time that you commence working garboard, provided the strapping has all been fitted and fastened and work upwards. Commence edge-bolting the bilge strakes as you work them, one bolt in each frame space in every strake.

Shift Butts.—In adjacent strakes the butts should shift at least 9 feet with one strake between at least 6 feet; with two strakes between at least 3 feet.

Top Side Planking.—At the same time commence to plank at the top side.

Decks.—Decking should be outgauged and the seams should not be larger than 3/32″ dressed half the thickness of plank. The 4″ decks should be fastened with 7/16″x7″ galvanized spikes in place of ½″x8″, as the latter owing to their size split ends of plank and beams.

Calking.—No outside calking should be driven until planks are fully fastened and treenails wedged on both ends, and no nearer to a strake's edge than four seams. Ceiling calking and wedging not to be done until all fastening is in.

The first thread should be cotton. The balance of the seams to be fitted with oakum and horsed. The seam shall be ⅛″. The outgauging, 1/16″ for each plank. All seams to be reamed before calking. Depth of outgauging will be one-half the depth of planking. No calking will be permitted until after the ship is planked to the turn of the bilge and at no time shall the calking be nearer than four seams from the opening.

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CHAPTER X

HAND TOOLS

Among the special hand tools used in wooden boat and ship building, the most important are the *adze,* the *broadaxe, calking irons,* the *calking mallet,* and *ship auger bits.* A description of each of these and their respective uses is given below.

A complete list of the hand tools used by the ship carpenter and boat builder is as follows:

Adze—lipped

Axe—plain broad

Bevel—ship carpenter's

Bits—
- extension
- screwdriver (large and small)
- ship auger with spur ¼″ to 1″

Brace—ratchet

Burr set

Calking irons

Calking mallet

Chisels—
- Cape
- cold
- slice, 2½″
- wood, ¼″ to 2″

Dividers

Draw knife

Gauges—
- marking
- wood, ¼″ to 2″

Hammers—
- ball pein
- claw

Oilstone

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Pinch bar, 20″

Planes—
- baller, for hollowing plank
- bilge, for smoothing side of hull
- compass
- fore
- jack
- rabbet
- smoothing

Pliers—end cutting

Plumb bob

Rasp—wood

Reamers—wood, ½″ to 1½″

Saws—
- compass
- cross cut
- hack
- panel
- rip

Spirit level

Spoke shave

Squares—
- large steel
- small try square, 7½″

Adze.—Figures 117, 118. The adze is a tool resembling a hoe and is used in much the same manner for shaping large parts where the wood to be removed is too much for the chisel or the plane. The lipped adze has the extreme ends of the blade turned up and is by far the best kind, as these lips insure a clean cut and prevent raising splinters. For the best results the cutting should be across the grain. See Figure 119.

For converting large material when machinery is not available, the roughing is done with a broad axe; the adze is next used to get close to the finish dimensions, and then the work is smoothed up with a plane.

Broad Axe.—Figure 120. This axe differs con-

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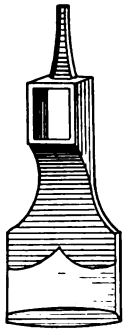

Figure 117.—Plain Adze.

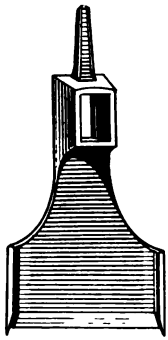

Figure 118.—Lipped Adze.

Figure 119.—Scarfing Timber with an Adze.

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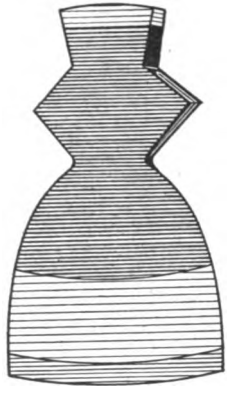

Figure 120.—Broad Axe.

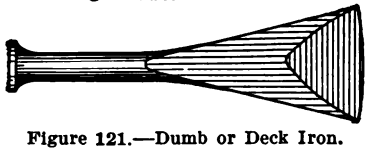

Figure 121.—Dumb or Deck Iron.

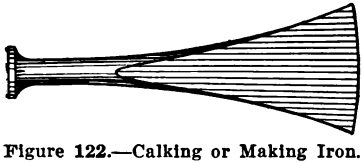

Figure 122.—Calking or Making Iron.

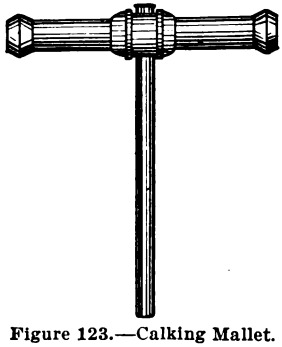

Figure 123.—Calking Mallet.

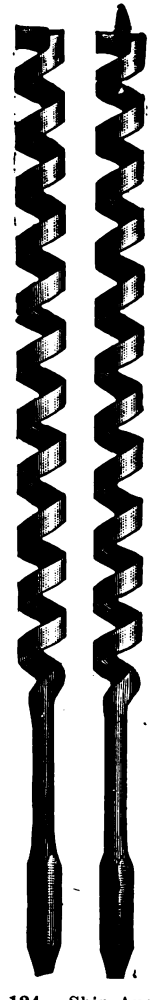

Figure 124.—Ship Auger Bits.

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siderably from the ordinary axe used for chopping. The blade is wide and is sharpened by beveling one side more than the other, somewhat like a chisel. Both blade and handle are offset, the whole form and hang being adapted to hewing on the side of large pieces of timber.

Calking Irons.—These are made of steel in various shapes and sizes. The two in general use are the dumb-iron (Figure 121), which has a tapered blade almost sharp, and the making-iron (Figure 122), which has a small blunt end with a channel in it, used for going over the cotton in the seams after it has been driven in by the driving-iron. The dumb-iron is employed to open the seams that are too tight.

Calking Mallet.—Figure 123. This is a tool used in connection with calking irons for driving cotton or oakum into the seams, to make them watertight. The head, which is long and small in diameter, is usually made of live oak and fitted with iron rings to add weight and prevent splitting. Several sizes are made, the smallest being suitable for boat work.

Ship Auger Bits.—Figure 124. These are used for boring long holes. They are of different shapes and are made with and without the feed screw, or spur. Those without the spur, sometimes called "barefooted," are preferred for very long holes, as they are not so readily deflected from a straight course. The commercial bits are often too short, but it is a small job for a blacksmith to weld in a piece, making any length required.

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CHAPTER XI

WOODEN BOAT AND SHIP TERMINOLOGY

Abaft.—Aft, in or at the back or hind part of a vessel, or the parts which lie toward the stern, opposed to forward.

After-timbers.—The timbers abaft the midship section of a vessel.

Air-port.—A small opening cut in the side of a vessel to admit light and air, closable by a shutter, sidelight or deadlight.

Apostle.—A knighthead or bollard-timber on a deck, for belaying hawsers and heavy ropes.

Apron.—An upper member of the stem on the inboard side of a boat.

Arch-board.—The part of the stern over the counter, under the knuckles of the stern timbers.

Auger-bit.—A boring-bit with a twisted shank, which clears the chips out of the hole.

Back Stays.—Long ropes extending backward from the heads of all masts above the lower mast and fastened on each side of the ship to the chain plates, serving to support the masts.

Balance-frames.—Those frames of a ship which are of equal area and equally distant from the ship's center of gravity.

Balcony.—The stern gallery of a ship.

Batten.—A thin strip of wood used in fairing lines.

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Beak.—A powerful construction of metal as steel, iron or brass, or of timber sheathed with metal, forming a part of the bow of many war-ships and extending below the water line for the purpose of striking and breaking in the sides of an enemy's ship.

Beak-head.—That part of a ship forward of the forecastle, fastened to the stem and supported by the main knee.

Beam.—The widest part of a vessel's hull, the extreme breadth of a vessel. One of the curved transverse timbers of a vessel supporting the deck.

Beam-line.—The line indicating the intersection of the top of the beams with the frame.

Bearding-line.—The line made by the curved surface of a ship's skin with the stem, keel and stern-post.

Bend.—The thick planks in a ship's side below the waterways or the gun deck port-sills, more properly called wales.

Bending Strake.—One of two strakes wrought near the deck coverings, worked all fore and aft. They are about 1″ or 1½″ thicker thar the remainder of the deck, but are lowered between the beams and ledges to make the upper side even with the rest. Their use is to make a more complete tie between the deck-frame and deck-plank.

Bevel.—Any angle in a timber except one of 90 degrees.

Beveling.—The angles which the sides and edges of each piece of a frame make with each other.

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Beveling Board.—A flat board upon which the bevelings of the various portions of the frame work of a vessel are marked.

Beveling-edge.—The edge of a ship's frame which is in contact with the skin.

Bilge.—The point at which frames turn from bottom to side of a vessel.

Bilge-keel.—A piece of timber fastened edgewise under the bottom of a ship for the purpose of keeping her from rolling heavily and from drifting to leeward.

Bilge-keelson.—A timber extending fore and aft in a ship inside the bilge to strengthen the frame.

Bilge-planks.—Strengthening planks of the inner or outer skin, at the bilge.

Bilge-way.—The foundation of the cradle supporting a ship upon the sliding-ways during building and launching.

Binding-strakes.—Thick strakes, planking, or wales, at points where they may be bolted to knees, shelf-pieces, etc.

Body-plan.—An end elevation of a hull, showing the water lines, buttock and bow lines, diagonal lines, etc.

Bollard.—A strong post fixed vertically alongside of a dock on which to fasten hawsers for securing or hauling vessels.

Bollard-timber.—One of two timbers or stanchions rising just within the stem, one on each side of the bowsprit to stiffen it latterly.

Bolt-strake.—The strake or wale through which the beam fastenings pass.

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Bow-lines.—Curves representing vertical sections of the bow end of a ship.

Bowsprit.—A large spar which projects forward from the stem of a vessel.

Break.—An abrupt change of level, as of a deck. The *break* of a poop-deck is where it ends forward.

Breast Hook.—One of the thick pieces of timber shaped in the form of knees and placed directly across the stem of a ship to strengthen the foremast and unite the bows on each side.

Bridge.—A raised platform extending from side to side of a ship above the rail, forward of amidship, for the use and convenience of the officers in charge.

Broad Strakes.—All planks below the shutter strake and above the garboard.

Building-block.—One of the temporary structures resting upon a slip and supporting the keel of a ship while building. They consist of blocks of timber so arranged as to be removable by knocking out the key-pieces or wedges.

Building-slip.—A yard prepared for shipbuilding. It includes one or more *slips,* or inclined planes on which a vessel in its cradle is supported while on the stocks in the process of construction, or upon which a ship is hauled for repair.

Built-up.—Composed of several parts joined together, as built-up frames.

Bulge.—Same as bilge.

Bulkhead.—A partition in a ship which divides the interior space into compartments, which may

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be made watertight. The bulkheads affording the greatest protection are those placed a few feet from the stem and stern respectively, the forward one checking the inflow of water through a damaged stem, and the after one averting the danger of any accident that might arise to the sternpost or rudder-braces, or to the tube of the shaft of screw-vessels. The water taken into these compartments would only slightly impede the way of the ship by throwing her out of trim, as the quantity would be comparatively small. The bulkheads more amidships assist in strengthening the vessel, and serve to prevent fire from spreading beyond the compartment in which it started. In case of a leak they confine the water to the compartment which it enters. Watertight bulkheads have been used for ages in Chinese shipbuilding, but in this country are more generally employed in iron than in wooden vessels. In small vessels they can only be used transversely, but in larger ones they may be applied longitudinally as well.

Bulwark.—A close barrier running around a ship or a part of it, above the level of the deck and consisting of boarding nailed on the outside of the stauchions and timber heads.

Butt.—The end of a plank or piece of timber which exactly meets another endwise in a ship's side, also the juncture of two such pieces.

Buttock.—The rounded-in, overhanging part on each side of a ship's stern in front of the rudder. It terminates below by merging into the *run.*

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Buttock-lines.—The curves shown by a vertical longitudinal section of the after part of a ship's hull, parallel to the keel. A similar section forward shows the *bow-lines,* and a continuous section through the whole length of the ship exhibits the buttock and bow lines.

Calking.—The process of filling the seams of a vessel with cotton or oakum to make them water tight. The seam is opened with a dumb-iron or deck-iron, driven with a calking mallet and the threads of cotton or oakum are driven in one after another with a calking iron or making iron, forcing the oakum below the surface and the space outside of it is filled with putty, cement or melted pitch.

Camber.—A curvature upward, like the rise or crown of a deck amidships, or of a bridge or a beam; the curve of a ship's plank. This shape is given to increase stability.

Cant.—A ship's timber near the bow or stern lying obliquely to the line of the keel.

Cant-frames.—Bow and stern frames canted from vertical position for the purpose of eliminating greater bevels.

Cant-timber.—A ship timber that is not square with the keel, or that makes an angle with the keel of less than 90 degrees.

Carling.—A piece of timber in a ship running fore and aft from one deck beam to another and forming with the beams a framing for the deck planks to rest upon.

Cat-beam.—The longest beam of a ship and one of the principal ones.

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Ceiling.—That portion of the inside skin of a vessel between the deck-beams and the limber-strakes on each side of the keelson. It is also called the *foot-waling*. The strakes of the ceiling immediately below the shelf-pieces which support the deck-beams are called *clamps*. The outside planking is called the *skin*.

Center-line (*C. L.*).—The central, longitudinal, vertical section of a vessel's hull.

Chain-plate.—One of the plates of iron bolted below the channels, for the attachment of the dead-eyes to which the shrouds and backstays are secured.

Chain-wale.—See *Channel.*

Channel.—A corruption of *chain-wale.* A flat ledge of wood or iron projecting outward from the ship's side, for spreading the shrouds or standing rigging at each side of the masts, and protecting the chain-plates. The channels are at the level of the deck beams.

Chock.—1. A block, usually wedge-shaped, driven behind the props of a cradle to prevent it from slipping on the ways before the ship is ready to launch.

2. A piece of timber, framed into the heads and heels of a ship's timbers at their junctions, to act as a lap to the joint and make up the deficiency at the inner angle, as in the stem-piece and the main piece of the head; also in the deadwood, etc.

Clamp.—A thick plank on the inner part of a ship's side used to sustain the ends of the beams.

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Clinch Ring.—An open ring placed over a nail or rivet before riveting the end down, thus drawing the planks firmly together.

Clinker-built.—A term applied to boats in which the lower edge of each plank overlaps the one next below it, like the weather-boarding of a house, or the shingles or slates of a roof. In such boats the lower edge of each strake of plank overlaps the upper edge of the next strake below. They are not built upon frames but upon temporary transverse sectional moulds, two, three, or four in number, which are fixed at their proper stations on the keel. The strakes are then put on, beginning with the garboard strake, and bent to the figure given by the moulds. Each strake is fastened to the next below it by nails, driven from the outside through the laps or *lands,* or by screws. When two or more lengths of plank are used in a strake, they are scarfed to each other, the outside lap of each scarf pointing aft.

Coal-bunker.—One of the spaces provided in a ship, convenient to the furnace-room, for keeping the fuel.

Coamings.—Also spelled *combings.* The raised border or frame of a hatchway, to prevent the water on deck from flowing below. The fore and aft pieces of a hatchway frame are *coamings,* those athwart ship are *head-ledges.* The former rest on *carlings,* which extend from beam to beam, and the latter rest on the deck beams.

Companion.—A wooden covering over the stair-

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way to a ship's cabin; a companion-hatch. The staircase is the companion-ladder, or companion-way.

Counter.—That part of a ship's stern which hangs over the stern-post. The counter-timbers spring from the *wing-transom,* which extends across between the *fashion-pieces,* crossing in front of the stern-post, near its head. At the top of the counter-timbers is the *taff rail.*

Counter Timbers.—Short timbers in the stern used to strengthen the counter.

Cradle.—The frame in which a ship lies on the ways, and which accompanies her into the water in launching, separating from the ship by the act of floating. In its simplest form, the cradle consists of three longitudinal timbers, united by ribs or crosspieces. It is also used in hauling out a ship for repairs.

Cross-beam.—A beam in a frame laid crosswise.

Cross-spalls.—Cross timbers uniting the heads of two futtocks.

Cutwater.—The forward edge of the stem or bow of a vessel; that which divides the water right and left. It is fayed to the forepart of the stem.

Deadeye.—A round laterally flattened wooden block, encircled by a rope or an iron band and pierced with three holes to receive the lanyard, used to extend the shrouds and stays and for other purposes.

Dead Light.—A strong wooden or iron shutter

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fastened over a cabin window or port hole in rough weather to prevent water from entering.

Deadwood.—The lower member of the stem or stern on the inboard side of a boat; also the solid mass of built-up timbers at the narrow portions of the extremities of a ship's frame, fore and aft, above the keel, and continued as high as the *cutting-down* line. In vessels designed for service in arctic waters, the deadwood is in unusual quantity, to give solidity to a structure liable to contact with ice-floes and drifts.

Dead-works.—The parts of a vessel above the load water line.

Deck.—Any floor in a ship above the bottom of the hold. Decks may run from stem to stern, or be only partial. In three-decked ships the decks above the water-line are known as the upper, main, and lower decks. The deck next below the water-line is known as the orlop deck. The upper may be known as the spar deck, with the forecastle as its foremost part and the quarter deck aft. The *waist* is the space amidships. A transverse deck extending across the middle of the vessel is called either a hurricane-deck, a bridge-deck, or the bridge. Detached structures on a deck are called deck-houses.

Decking.—Plank covering for a deck.

Deck Transom.—A beam or frame work across the stern of a vessel supporting the after part of the deck.

Diagonal.—1. A timber brace, knee, plank, truss, etc., crossing a vessel's timbers transversely.

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2. A line cutting the body plan diagonally from the timbers to the center line.

3. An oblique brace or stay connecting the horizontal and vertical members of a truss or frame.

Diagonal-built.—A term applied to boats in which the outer skin consists of two layers of planking making angles of about 45 degrees with the keel in opposite directions. Such boats are built, like clinker-built boats, upon temporary transverse moulds. After setting up and fixing the moulds upon the keel, the gunwale, a shelf-piece, and a series of ribbands are temporarily fixed in the moulds. Two layers of planking are then put on, bent to fit the moulds and ribbands, and fastened to each other and to the keel, stem, sternpost, shelf, and gunwale with screws or nails, driven from the outside, and clinched inside upon small rings, called *clinch-rings* or *roves*. The gunwale is then shored, to keep it in shape. The moulds and ribbands are taken out, and floors, thwarts, etc., are put in as in a clinker-built boat.

Diagonal-lines.—Lines showing the boundaries of various parts, formed by sections which are oblique to the vertical longitudinal plane, and which intersect that plane in straight lines parallel to the keel.

Displacement.—The weight of water displaced by a vessel floating in it, this weight being equal to the weight of the ship.

Diminishing Stuff.—Planking worked under the strakes and thinned to correspond with the thickness of the bottom plank.

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Dog-shore.—One of the two struts which hold the cradle of the ship from sliding on the slip-ways when the keel blocks are taken out. The lower end of each dog-shore abuts against the upper end of the ribband of the slip-way, and the upper end against the *dog-cleat,* which is bolted to the side of the bilge-way. Beneath each dog-shore is a small block called a *trigger.* In launching, the triggers are removed, the dog-shores knocked down, and the ship-cradle freed, so that, carrying the vessel, it slides down the slip-ways. A time-honored signal for launching is "Down dog-shores!"

Double Futtocks.—Timbers in the cant-bodies extending from the deadwood to the run of the second futtock-head.

Draft.—The depth of water which a ship draws or requires to float it.

Drift-piece.—One of the upright or curved pieces of timber that connect the plank-sheer with the gunwale.

Dubbing.—Dressing a timber smooth with the adze.

Entering-port.—A port or opening cut in the side of the vessel to serve as a door of entrance.

Entrance.—The bow of a vessel or form of the forebody under the load water line, opposed to run.

Expansion.—The expansion of the skin of a ship, or rather of a network of lines on that surface, is a process of drafting to facilitate the laying-off

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of the dimensions and positions of the planks of which that skin is to be made.

Fair.—To make in true curves or proportions; to make regular, true, smooth, or flowing the lines of a boat or ship.

False Keel.—A set of timbers worked onto the main or true keel out-board, and intended to prevent leeway, also to protect the true keel in case of grounding.

Fay.—To fit close together, as two pieces of wood or timber.

Faying Surface.—The face or end of a piece of timber which joins another similar surface so closely as to leave no space or crevice.

Filling.—Pieces of material or a composition fitted in between the frames of the hold, to increase the watertightness, resist compression, and prevent the accumulation of dirt, bilge-water, and vermin. Blocks of wood, bricks, mortar, cement, and asphalt have been used.

Flat.—One of a number of ship's frames of equal size and forming a straight middle body; also a timber which has no curves, as the floor-timbers of the *dead-flat* amidships.

Flitch Timber.—One of several timbers fastened side by side to form a compound frame made of wood having a natural bend used at turn of bilge to increase stability.

Floor.—The bottom part of the hold on each side of the keelson; the flat portion of a vessel's hold.

Floor Timbers.—Cross timbers uniting the heels of two futtocks.

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Flush Deck.—A deck running the whole length of the ship, from stem to stern, without forecastle or poop.

Forebody.—That part of a ship which lies forward of the midship section.

Forecastle (pronounced fōke'sl).—The part of a ship forward of the foremast; a forward part of the space below decks, for the accommodation of seamen; in flush decks, a part of the upper deck forward of the after fore shroud; or a short upper deck forward.

Forefoot.—The forward end of a vessel's keel, on which the stem-post is stepped.

Fore-hook.—A strengthening piece in the stem, binding the bows together; also called a breast-hook.

Foremast.—The mast nearest the bow in vessels carrying more than one mast.

Frame.—A built-up rib of a wooden vessel. Two or more futtocks united form a frame.

Frame Mould.—A pattern or template for the frame of a boat or ship.

Freeboard.—That part of a vessel's side which is included between the plank-sheer and the water-line.

Furring.—Double planking of a ship's side.

Futtock.—One of the curved or crooked timbers in a built-up or compound rib or frame of a vessel. A timber of the dimensions and form for a frame of a ship cannot be procured in one piece; the frame is built up of pieces scarfed together.

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The number required is according to the length of the sections of the requisite height. They are known as the first, second, or third futtock, terminated by the top-timber. The term futtock is also applied to the complete half of a frame.

Futtock-plank.—The first plank of the ceiling next to the keelson; also called the *limber-strake.* The first plank of the skin next to the keel is the *garboard-strake.*

Gallery.—A balcony projecting from the after part of a ship, as the quarter-gallery or stern-gallery.

Galley.—1. A clinker-built boat for ship's use, from 28 to 36 feet long, rowed by ten or twelve men.

2. The cook-house on board ship, which is on deck or in a forward part of the vessel.

Gangway.—An opening in the bulwarks of a vessel by which persons come on board or disembark.

Garboard Strake.—The row or strake of planks nearest to the keel on the outside of a ship's bottom. The rabbet to receive the garboard strake is made along the upper edge of the keel.

Ground Timbers.—The timbers which lie on the keel and are bolted to the keelson.

Ground-ways.—The large blocks and planks which support the cradle on which a ship rests and is launched.

Gunwale.—The upper planking covering the timber heads around the topside of the ship; also the

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piece of timber around the topside of a boat, and having rowlocks for the oars.

Half-breadth Plan.—A plan or top view showing the horizontal or floor plan on any water line.

Half-Floor.—One of the timbers of a frame, the heel of which is over the keel, while on its head rests the heel of the second futtock. It lies for half its length alongside the cross-timber, with the other half alongside the first futtock.

Half Timber.—One of the short futtocks in a cant-frame.

Hanging Knees.—Knees placed vertically to the deck.

Harping.—A continuation of the ribbands beyond the square frames, moulded to the shape of the hull and used for proper spacing of cants and futtocks. The term harpings is also applied to the plank wales of the bow, which are of extra strength. Also spelled *harpin.*

Hatch.—An opening in a deck or floor, or the covering for the same.

Hatchway.—One of the large rectangular openings in the deck of a ship by which freight is hoisted in or out, and access is had to the hold. The coverings are *hatches,* and these are fastened down by *battens.* There are four pieces in the frame of a hatchway, including the coamings and head-ledges. The hatchways are called fore hatch, or main hatch, or after hatch, as the case may be, according to the size and character of the vessel.

Hawsehole.—A hole in the bow through which a

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cable or hawser may be passed. In large ships the hawseholes are four in number.

Hawse-piece.—One of the cant-frames standing next to the knightheads, and fitted close together, so as to form a solid mass of timber for the passage of the hawseholes; also a plank or strake on the ship's bow which is pierced by the hawse-hole.

Hawse Timber.—One of the upright timbers in the bow, bolted on each side of the stem in which the hawseholes are cut.

Hawse Wood.—A general name for the hawse timber.

Hawser.—A cable, especially a small cable or a large rope in size between a cable and a tow-line used in warping.

Head.—1. The fore part, beak, bow, or stem end of a vessel.

2. The upper part of a timber in a frame. The other end is the *heel.*

3. The forefoot of the keel.

Headledge.—A thwartship piece used in framing the hatchways or ladderways.

Heel.—The lower end of a timber in a frame; the after end of a ship's keel.

Hog-frame.—A fore-and-aft frame forming a truss in the main frame of a vessel, to assist in giving vertical rigidity to the structure.

Hold.—The interior part of a ship, in which the cargo of a merchant vessel is stored. The portions are distinguished as the fore, main and after holds.

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Horn Timber.—A small timber to protect the end of the stern-post and to eliminate end wood.

Horse.—To embed firmly in the seams of a ship as oakum with a horsing iron and a mallet.

Horsing Iron.—A large calking iron with a long handle, held by one man and driven by another.

Hull.—The body of a ship or boat, exclusive of the masts, yards, sails, and rigging.

Hurricane Deck.—A raised platform extending from side to side of a ship, above deck amidships; a bridge or station for the officer in command.

Inboard.—Inside a ship's hull.

Inner Post.—A piece brought in at the fore side of the main post, and generally continued as high as the wing transom to seat the other transoms upon.

Keel.—The lower longitudinal beam or member of the framework of a vessel, serving as the backbone of the entire frame. When a ship is to be built the keel is first *laid,* upon blocks of which the upper surfaces from an angle of about three degrees with the horizon. These are called *keel-blocks* and are usually about three feet high and spaced about four feet apart. White oak is a favorite material for the keel.

Keel Block.—One of a series of short timbers on which the keel of a vessel rests while building or repairing which affords access to work underneath.

Keelson.—A beam running lengthwise above the keel, and bolted to the middle of the floor

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frames, binding them to the keel, in order to stiffen the vessel.

Knee.—Any one of the angular pieces of timber or iron connecting the beams and the frames of a vessel.

Knighthead.—One of the first cant timbers on each side of the stem, rising obliquely from the keel and passing on each side of the bowsprit, to secure its inner end.

Land.—The lap of the strakes in a clinker built boat. Also called *landing.*

Lanyard.—A rope rove in the deadeyes of the rigging for setting up and tightening the shrouds, backstays, etc.

Leeward.—Toward the lee or that part toward which the wind blows: opposed to windward.

Limber.—A passage on each side of the keelson for bilge water. It is covered by a movable plank called a limber-board, the edges of which rest respectively upon the keelson and the limber strake.

Limber Strake.—The strake of the inner skin of a ship which is nearest to the keelson.

Lines (on a Drawing).—The principal lines of a ship plan or drawing are as follows:

(a). Base Line.—A horizontal reference line from which vertical measurements are taken.

(b). Center Line.—A vertical line in the center of the body plan, perpendicular to the base line. A horizontal line on the half-breadth plan through the center of the vessel.

(c). Diagonals—Lines running diagonally from the center line to frame lines.

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(d). Frame Lines—Outlines showing the shape of the frames of the vessel.

(e). Water Lines—Horizontal lines parallel to the base line in the body plan; horizontal lines parallel to the base line in the sheer plan; curved lines in the half-breadth plan.

Lines Plan.—A drawing showing the general outline or form of the vessel. The lines plan comprises three plans:

(a). Sheer Plan—A side view showing the length of the vessel and heights of the sheer or gunwale.

(b). Half-breadth Plan—A top view showing the horizontal or floor plan on any water lines.

(c). Body Plan—An end view showing the curves of the sides or frame lines at any point in the vessel. Frame lines forward of the midship section are on the right of the center line; those aft of the midship section on the left of the center line.

Load Water-line.—The line of flotation of a ship when it has its full cargo aboard.

Lodging Knees.—Knees fixed parallel to the deck.

Loftsman.—A man who lays out and makes moulds for a vessel.

Mast.—A long spar placed amidships, nearly perpendicularly upon the keelson, and serving to support yards, sails, and rigging, or in steam vessels for signaling, hoisting, and other purposes. The lower end, or heel, of a mast rests in a *step* on the keelson.

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Mast-hole.—A framed hole in the deck to receive a mast. It is made of larger diameter than the mast by twice the thickness of the wedges which hold the mast in position.

Mould.—A full-size pattern of the same figure and dimensions as the moulding-side of the piece which it represents. The mould may be of skeleton form and may serve for several frames. It is usually a thin plank cut to the form of a ship timber and serves as a template for scribing the members for the workmen, who saw, hew, and adze them into shape.

Moulding.—The depth or dimension (of a piece of timber) which lies in the moulding-plane.

Moulding-edge.—That edge of a ship's frame, which comes in contact with the skin and is represented in the plan. The other edge is the *beveling-edge.*

Mould Loft.—A large open room on the floor of which drawings and moulds of a vessel are laid out full size.

Oakum.—Junk or old rope untwisted and picked into lose fibers resembling tow; used for calking the seams of vessels, stopping leaks, etc.

Orlop.—The deck below the berth deck in a ship where the cables were formerly coiled.

Pintle.—That part of the hinge of the rudder which consists of a verticle pin designed to receive the ring of the other part. It is generally set in the stern-post with the pin erect, but in small boats the pintle is often attached to the rudder, in which

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case the pin projects downward entering the ring from above.

Planking.—The skin, or wooden covering of plank on the exterior and interior surfaces of the ribs or frames, and on the beams of a vessel. A line of planking is a *strake,* and is named from its position, as garboard strake, sheer strake, etc.

Planking-clamp.—A clamp used for bending a strake against the ribs or frames of a vessel and holding it until secured by bolts or treenails.

Plank-sheer.—A plank resting on the heads of the top timbers of the frames or ribs; the gunwale.

Pointer.—A diagonal fore and aft timber connecting the stem and stern frame with the fore and after body.

Poop.—A short deck built over the after part of a vessel, also called poop-deck; the aftermost, highest part of the hull.

Port.—1. A framed opening in a ship's side, closed by glazed lids called *sidelights,* or by watertight shutters, called *deadlights.* An airport is an opening through the side below decks for ventilation.

2. The left side of a vessel to a person standing on deck and facing forward; formerly called *larboard.*

Port-hole.—An embrasure in a ship's side.

Pump-well.—A compartment extending from the ship's bottom to the lower or the upper deck, as the case may be, to contain the pump-stocks, etc.; used to remove bilge water which collects in the limbers, or in the event of a leak.

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Quarter.—The side of a ship, aft, between the main channels and the stern.

Quarter-deck.—A deck raised above the waist and extending from the stern to the mainmast in a full-rigged ship.

Rabbet.—The recess cut in the keel, stem, and stern to receive the ends of planking.

Rail.—The top of the bulwarks of a ship. The part continued round the stern is the taffrail.

Rake.—The forward pitch of the stem of a vessel, or backward slope of the stern, that is, the degree in which it overhangs the keel. The rake of a rudder is that of the stern-post.

Ram.—A steamship of war armed at the prow below the water line with a heavy metallic beak or spur, intended to destroy an enemy's ship by the force of collision.

Reaming-iron.—A blunt chisel used for opening the seams between the planking of a ship, before calking them with oakum.

Rib.—One of the curved side timbers of a ship or boat, to which the wooden planking and the interior sheathing is treenailed or pinned. These frames are called ribs from their resemblance in form and function to the ribs of the human body. They are fastened to the keel or backbone of a ship in much the same manner as the human ribs are articulated to the spine. For wooden vessels of considerable size, timber of the required dimensions and form cannot be procured to make a rib of one piece, so each rib or frame is made of sec-

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tions scarfed together. These sections are called *futtocks*.

Ribband.—A temporary lengthwise strip following a vessel's curves and bolted to its ribs on the square body to hold them in place until they receive the planking or plating. A number of these are fastened at different distances from the keel.

Ribband lines.—One of the diagonal lines on the body plan, by means of which the points called sur-marks where the respective bevelings are to be applied to the timbers, are marked upon the moulds.

Ribband nail.—A nail having a large round head with a ring to prevent the head from splitting the timber or being drawn through, used chiefly for fastening ribbands. Also written ribbing nail.

Ribband shore.—A square timber of the ship fastened lengthwise in the bilgeways to prevent the timbers of the cradle from slipping outward during launching.

Rider.—A rib within the inner sheathing, bolted through the latter into the main ribs and planking, for the purpose of stiffening the frame. The riders extend from the keelson to the orlop-deck beams.

Riding-bitts.—Two strong upright timbers near the bows of a ship, to which the cable is secured; they extend through two decks, are connected by a crosspiece, and braced against the strain of the cable by horizontal standards bolted to the deck beams.

Rising-line.—A curved line on the plans of a

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ship, marking the height of the floor timbers throughout the length, and thereby fixing the sharpness and flatness of the vessel's bottom.

Risings.—Thick planking laid fore and aft in which the timbers of the deck bear; also the narrow strake inside a boat just under the thwarts.

Rove.—A diamond shape washer placed over the end of a rove clench nail.

Rove Clench Nail.—A clench nail with a square end.

Rudder.—A contrivance, usually consisting of a flat frame, hung to the stern-post of a vessel, to afford a means of steering. The *pintles* of the rudder are hooked upon the eyebolts of the stern-post, thus giving an axis of oscillation as the rudder is moved to and fro by the *tiller*.

Rudder-port.—The hole in a ship's counter for the passage of the rudder-head, or upper cylindrical end.

Run.—The extreme afterpart of a ship's bottom or of the hold; opposed to entrance.

Scaling.—The process of developing the proper diminish of a plank fore and aft.

Scantling.—The dimension or size prescribed for any part of the hull of a ship, especially the transverse dimension of pieces of timber.

Scarf.—A lapped joint made by beveling off, notching or otherwise cutting away the sides of two timbers at the ends, and bolting or strapping them together so as to form one continuous piece, usually without increased thickness. Also spelled *scarph.*

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Scupper.—A hole or tube leading through the ship's side, to carry away water from the deck.

Scuttle.—A small opening in a ship's deck or side, closed by a shutter or hatch.

Seam.—The space between two planks of a ship's skin, made water-tight by calking.

Shaft-alley.—A passageway between the after bulkhead of the engine room and the shaft-pipe, around the propeller shaft and affording a means of access thereto.

Shaft-log.—A member of the stern of a wooden vessel through which the propeller-shaft passes.

Shaft-pipe.—The pipe or tube in the stern of a vessel through which the propeller-shaft passes inboard. It occupies a hole bored through the stern-post and deadwood.

Sheathing.—A covering, usually thin plates of copper or of an alloy containing copper, to protect a ship's bottom.

Sheer.—The rise or upward curvature of the lines of a vessel's hull toward the bow and stern.

Sheer Batten.—A strip nailed to the ribs of a vessel to indicate the position of the wales or bends preparatory to fastening the planking on.

Sheer Plan.—A side view showing length of vessel and heights of sheer or gunwale, showing the outside form of the ship, stem and stern, water lines and square stations.

Sheers.—An apparatus, usually mounted on a wharf, for placing the masts in a ship, hoisting in and taking out boilers, etc. It consists of two

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masts, or legs, secured together at the top, and provided with ropes or chains and pulleys for hoisting purposes.

Sheer Strake.—Extreme upper plank, also called gunwale.

Shoe.—The outer piece of the cutwater of a vessel.

Shore.—One of the wooden props by which the framework of a vessel is externally supported while building; or by which the vessel is laterally supported on the stocks.

Shroud.—One of a set of strong ropes extending from a ship's mastheads to each side of the ship to support the masts.

Shutter Strake.—The last plank of the bottom to be installed.

Side Light.—A plate of glass in a frame fitted to an air-port in a ship's side to admit light.

Siding.—Dressing the timbers of a ship to the required thickness; also the timbers so dressed. The thickness of a timber in a direction perpendicular to the moulding plane.

Skeg.—A knee which unites and braces the stern-post and keel of a boat.

Skin.—The inner or outer planking of a ship. The inner skin is commonly called the ceiling.

Sliding-way.—One of the structures on each side of and parallel with the keel, supporting the bilge-ways of the cradle on which the vessel rests in launching. The sliding-ways are the inclined planes down which the vessel slides, and are made of narrow planks laid on blocks of wood.

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Slip.—An inclined plane on which a vessel in its cradle is supported while on the stocks building, or upon which it is handled for repairs.

Sny.—The trend of the lines of a ship upward from amidships toward the bow and the stern; a gentle bend in timber curving upward.

Snying.—Curved planking set edgewise in the frame of a vessel at the bow or stern.

Spiling.—The edge-curve of a plank or of a strake in a vessel's hull.

Spiling Batten.—A batten on which shapes of planking, or other scantlings, are laid out to proper shape.

Spilings.—Dimensions taken from a straight-edge or rule to different points on a curve.

Spur.—A shore or piece of timber extending from the bilgeways, and fayed and bolted to the bottom of the ship on the stocks.

Stanchion.—A post for supporting the deck-beams of a vessel.

Standard Knee.—A bent timber having one branch fastened against the upright side of a beam and the other against the ship's side. One fayed vertically to the vessel's side, above or beneath a beam, is called a *hanging knee.*

Starboard.—The right-hand side of a vessel, looking from aft forward; in contradistinction to *port,* the left-hand side, formerly called *larboard.*

Stem.—The foremost boundary of a vessel, being a nearly vertical continuation of the keel, into which the lower end is scarfed. The forward ends

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of the various strakes are united to the stem, and its advanced edge is the *cutwater.*

Stem-knee.—A knee at the junction of the stem with the keel.

Stemson.—A knee-piece with its horizontal arm scarfed to the keelson and its vertical arm fayed into the throats of the transoms.

Step.—The recessed block in which the foot of a mast is placed.

Stern.—The after part of a vessel, from the taff-rail down to the junction of the stern-post with the keel.

Stern-knee.—A knee uniting the stern-post and the keel.

Stern-post.—The timber forming the after boundary of a vessel being the continuation of the keel to the height of the deck and forms a receptacle for the after ends of the outside planking.

Stern-sheets.—The space in a boat abaft the thwarts in which the rowers sit.

Sternson.—A binding-piece above the deadwood in the stern, and practically forming an extension of the keelson, on which the stern-post is stepped.

Stocks.—The framework of blocks and shores on which a vessel is built. It slopes gently down toward the water, and is usually a timber frame which, as the work of construction proceeds, assumes the form of a cradle. This rests on *ways,* on which it eventually slides, bearing the vessel into the water at launching. The vessel is supported laterally by *shores,* while the cradle is held

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by *struts* and *chocks*. In launching the ship, the shores are removed, so that the vessel rests altogether in the cradle; the ways are greased, the struts are knocked away, the chocks knocked out, and the vessel slides down the ways into the water, where the cradle becomes detached and floats clear of the ship.

Stop Water.—A plug of soft wood driven tightly into a hole at the joint of a scarph, the expansion of which, when immersed, prevents water from working up through the scarph and behind the bottom planking.

Strake.—A breadth of planking or plating, especially one continuous from stem to stern on a vessel's hull. Strakes are named as follows:

(a). Binding Strake—The first plank directly below the upper strake and generally installed in one length if material permits.

(b). Bilge Strake—A strake passing over a vessel's bilge.

(c). Broad Strakes—All planks below the shutter strake and above the garboard.

(d). Garboard Strake—The extreme lower plank, next to the keel.

(e). Sheer or Upper Strake—The extreme upper plank.

(f). Shutter Strake—The last plank of the bottom to be installed.

(g). Lower Strakes—All planks below the binding strake and above the shutter strake.

Stringer.—An inside strake of plank, secured to

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the ribs and supporting the ends of the beams; a shelf-piece.

Surmark.—1. A mark drawn on ship timbers at the intersection of the moulding edge with the rib-band line; the stations of the ribbands and harpings being marked on the timbers.

2. A cleat temporarily placed on the outside of a rib, to give a hold to the ribband by which, through the shores, it is supported on the slip-way.

Taff rail.—The uppermost part of a ship's stern; the rail or topside of the bulwarks around the stern.

Template.—A pattern, guide or mould used to indicate the shape any piece of work is to assume when finished.

Thwart.—A seat across a boat on which the oarsman sits.

Tiller.—The bar or lever fitted to the head of a rudder and employed to turn the helm of a ship or boat in steering.

Topside.—The upper part of a ship's side.

Topside Line.—A sheer line drawn above the top timber at the upper side of the gunwale.

Top-timber.—The timber next above the futtocks in a built-up frame or rib.

Top Breadth.—A line in the sheer plan drawn to the sheer of the ship fore and aft, at the height of the under side of the gunwale amidships.

Transom.—A beam bolted across the stern-post, supporting the after end of a deck and giving shape to the stern.

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Transom-knee.—A knee bolted to a transom and after-timber.

Treenail.—A cylindrical pin of hardwood, used for securing planking to the frames, or parts to each other. Treenails are from 1 to 1¾ inches in diameter, and are tightened in their places by wedges driven into each end.

Trigger.—*A* wooden piece employed to hold up a dogshore. It is removed just before launching, when the dogshore is knocked away.

Trimming.—The final shaping of ship timbers, etc., after the rough shaping has been done; also called *forming.*

Waist.—The middle portion of a ship's deck, between the forecastle and the quarter-deck.

Wale.—A wide plank at certain portions of a ship's side, extending from stem to stern and following the curve of the *strakes.* The various wales are known as the *gunwale, main-wale, channel-wale,* etc.

Warping.—To move into some desired place or position by hauling on a rope or warp which has been fastened to something fixed, as a buoy, anchor or other ship at or near that place or position, as to warp a ship into harbor or to her berth.

Walking Beam.—The lever of a steam engine reciprocating upon a center and forming the medium of communication between the piston rod and the crank shaft.

Water Lines.—The lines of a ship drawn parallel with the surface of the water, at varying heights.

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In the sheer plan they are straight and horizontal; in the half-breadth plan they show the form of the ship at the successive heights marked by the water lines in the sheer plan.

Way or Ways.—The timber sills or track upon which a ship is built, and upon which she slides into the water in launching.

Windward.—Toward the wind; opposed to leeward.

Windlass.—A kind of hoisting machine in which an axis is turned by means of a crank handle or power and a rope or chain is thus wound around it so as to raise a weight. A windlass is much used in ships for raising anchors and raising cargoes.

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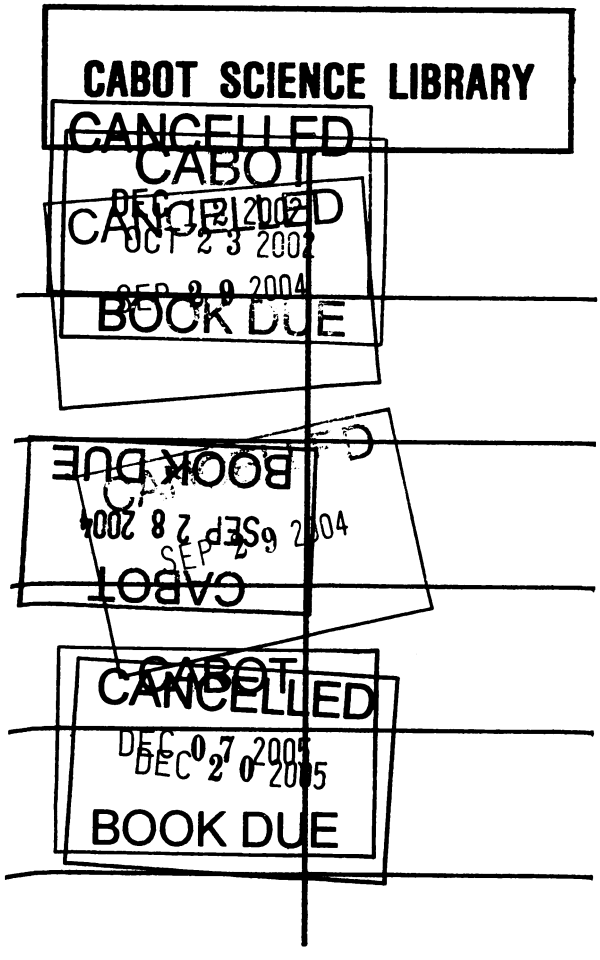

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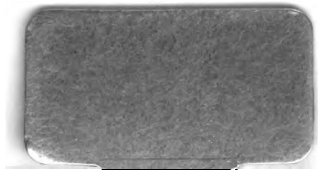

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